

Climate Change Part I:
Exposures, Vulnerabilities,
and Health Impact.
Focus on Air Quality

September 24, 2019 Salt Lake City, Utah

Jeffrey L Anderson, MD FACC FAHA MACP Professor of Medicine University of Utah Distinguished Clinical and Research Physician, Intermountain Medical Center Heart Institute

No financial conflicts to report

"Tipping Point" "Existential Risk"



### **Discussion Outline**

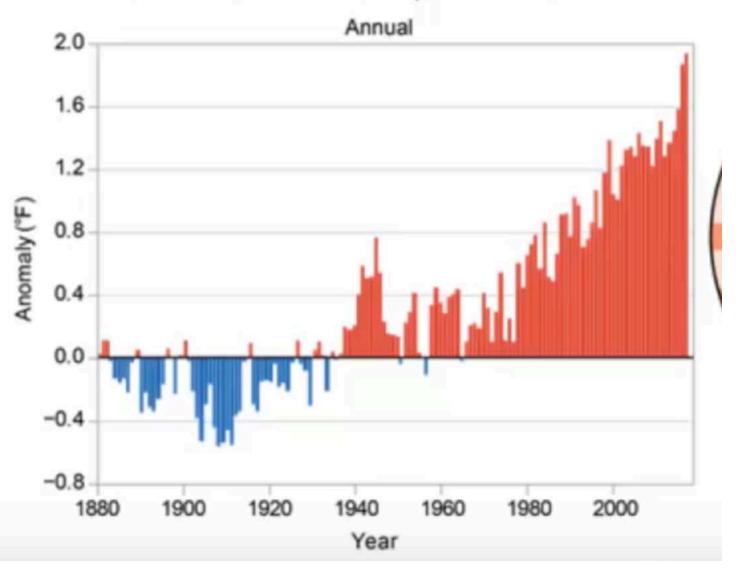
- 1) The earth is warming, and the cause is largely anthropogenic.
- 2) Outline of Lancet Countdown article
- 3) 8 indicators of hazards, vulnerabilities, and health impact
- 4) Air quality indicator and use of non-conventional transport fuels
- 5) Impact of air quality on health globally: NEJM 2019
- 6) Impact of air quality locally
- 7) CCL and carbon tax proposal as one solution



### **Climate Change Trends**

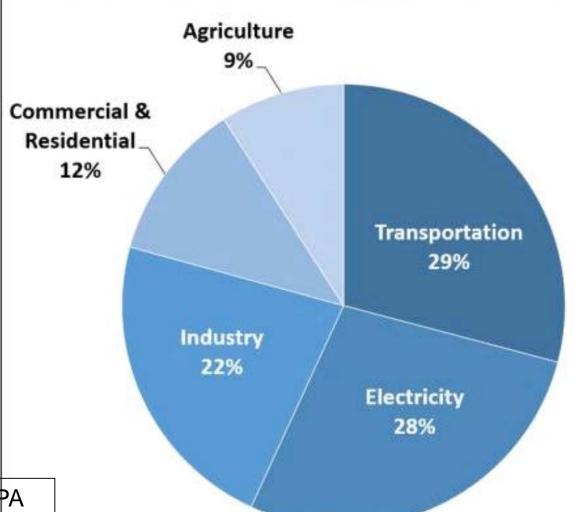


### Global Land and Ocean Temperature Anomalies



### What are the Sources of Greenhouse Gases (CO2, etc.)?





87% comes from the burning of fossil fuels

Data from EPA

### **Local Trends in Climate Warming**

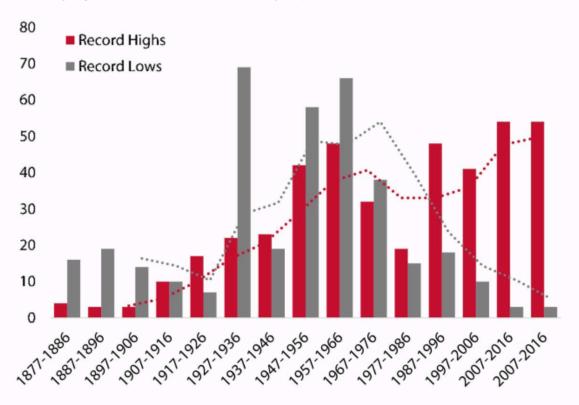




### High record temperatures more common than low record in recent decade

#### Salt Lake City temperature records

Number of daily high and low records set in each 10-year period

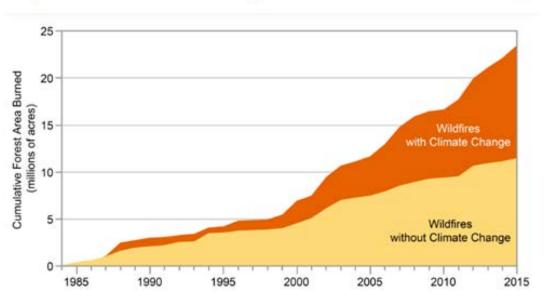


Note: Lines are 3-period moving averages

Sources: National Oceanic and Atmospheric Administration and Federal Aviation Administration

## Growing Impact of Climate Change on Wildfires





The cumulative forest area burned by wildfires has greatly increased between 1984 and 2015, with analyses estimating that the area burned by wildfire across the western United States over that period was twice what would have burned had climate change not occurred. From Figure 25.4 (Source: adapted from Abatzoglou and Williams 2016).



# Wildfires burned 485,989 acres in Utah this year — more than double for 2017

The Lancet Commission on Health and Climate Change concluded that "anthropogenic climate change threatens to undermine the past 50 years of gains in public health, and conversely, a comprehensive response to climate change could be 'the greatest global health opportunity of the 21st century"



Nick Watts, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, Wenjia Cai, Diarmid Campbell-Lendrug

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### Indicators to track health impacts of climate change:

**Section 1**: Measure exposure to climatic hazards and vulnerabilities of people exposed to them; quantify health impacts over time.

**Sections 2, 3:** Inform protective adaptations and mitigation interventions

**Section 4:** Inform economic and financial tools available to enable such responses

**Section 5:** Inform public and political engagement that facilitates them.

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### **Indicator 1.1:**

People experience far more health effects of temperature change than global mean temperature rise: people-weighted exposure far exceeds area-weighted exposure.

of the 2015 Lancet commission on Freatth and Change, which concluded that anthropogenic climate change threatens to undermine the past 50 years of gains in public health, and conversely, that a comprehensive response to climate change could be "the greatest global health opportunity of the 21st century".

The Lancet Countdown is a collaboration between

suggesting the beginning of an adaptive response to climate change. Yet the impacts of climate change are projected to worsen with time, and current levels of adaptation will become insufficient in the future. The total value of economic losses resulting from climate-related events has been increasing since 1990, totalling LIS\$120 billion in 2016, 90% of these economic losses in

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### **Greater People-Exposure (blue) versus Land Area- Exposure (red) to Increasing Summer Heat**

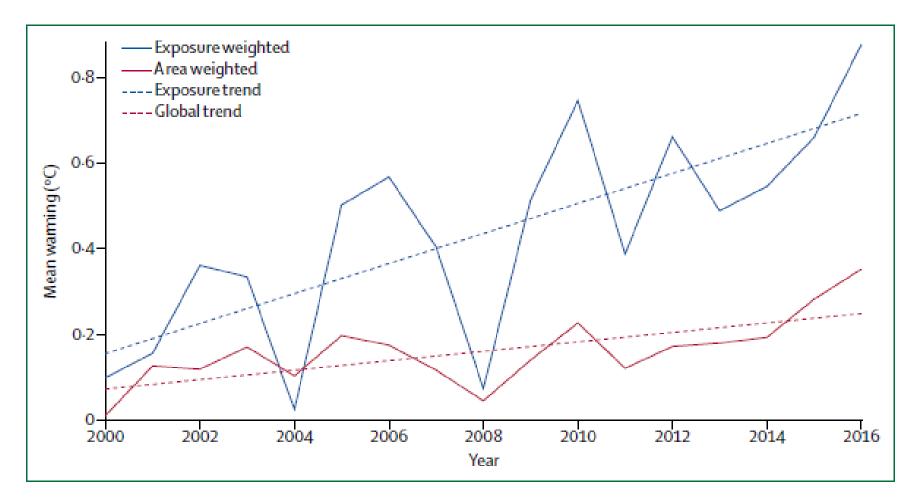


Figure 1: Mean summer warming relative to the 1986–2008 average

The time series are global mean temperatures calculated from the gridded data, weighted by area (to avoid bias from measurements near the poles) and by exposure (to show the number of people exposed).



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### Indicator 1.2:

The evidence is clear that exposure to more frequent and intense heatwaves is increasing, with an estimated 125 million additional vulnerable adults exposed to heatwaves between 2000 and 2016 and a record 175 million more people exposed to heatwaves in 2015.

in public health, and conversely, that a comprehensive response to climate change could be "the greatest global health opportunity of the 21st century".

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### Change in Heatwave Exposure in Vulnerable Elderly (vs. 1986-2008 average)

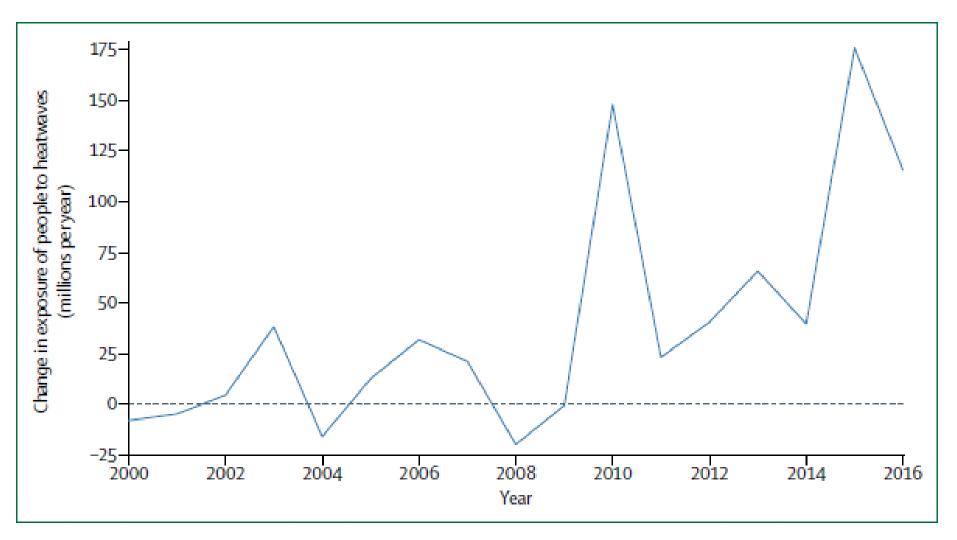


Figure 2: The change in heatwave exposure (in people older than 65 years), relative to the 1986–2008 average



Nick Watts, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, Wenjia Cai, Diarmid Campbell-Lendrum, Jonathan Chambers, Peter M Cox, Meaghan Daly, Niheer Dasandi, Michael Davies, Michael Depledge, Anneliese Depoux, Paula Dominguez-Salas, Paul Drummond, Paul Ekins, Antoine Flahault, Howard Frumkin, Lucien Georgeson, Mostafa Ghanei,

Delia Grace, Hilary Gra

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The Lancet Co climate change ment of the implementation Indicator 1.3:

From 2000 to 2016, increasing ambient temperatures have resulted in an estimated reduction of 5.3% in outdoor (rural) manual labor productivity worldwide.

implications of these actions. It follows on from the work of the 2015 *Lancet* Commission on Health and Climate Change,<sup>2</sup> which concluded that anthropogenic climate change threatens to undermine the past 50 years of gains in public health, and conversely, that a comprehensive response to climate change could be "the greatest global health opportunity of the 21st century".

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of these extreme events (Indicator 1.4), potentially suggesting the beginning of an adaptive response to climate change. Yet the impacts of climate change are projected to worsen with time, and current levels of adaptation will become insufficient in the future. The total value of economic losses resulting from climate-related events has been increasing since 1990, totalling LIS\$120 billion in 2016, 90% of these economic losses in

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### Labor Capacity Change Worldwide (vs. 1986-2008 average)

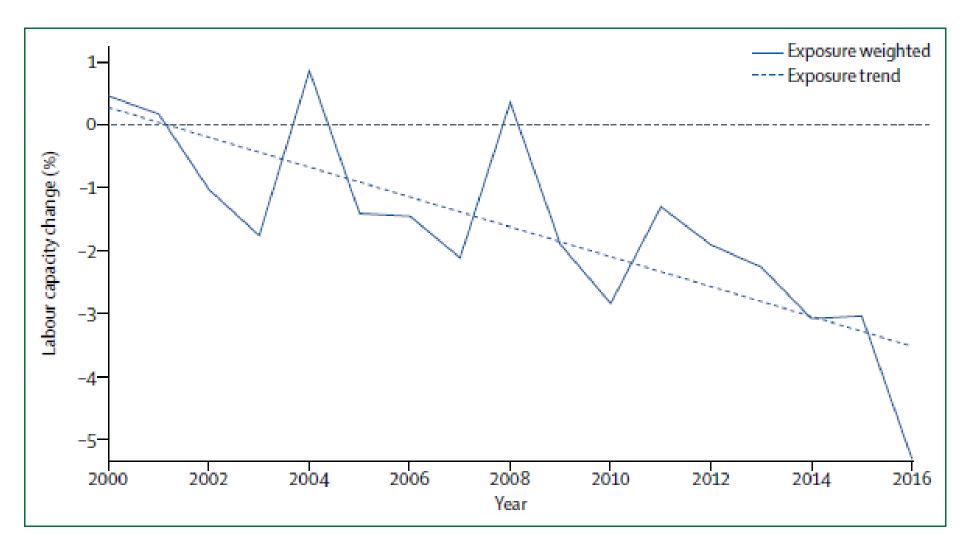


Figure 4: Labour capacity change worldwide, relative to the 1986-2008 average



Nick Watts, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, Wenjia Cai, Diarmid Campbell-Lendrum, Jonathan Chambers, Peter M Cox, Meaghan Daly, Niheer Dasandi, Michael Davies, Michael Depledge, Anneliese Depoux, Paula Dominguez-Salas, Paul Drummond, Paul Ekins, Antoine Flahault, Howard Frumkin, Lucien Georgeson, Mostafa Ghanei,

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### **Indicator 1.4:**

The frequency of weather-related disasters has increased by 46% from 2007 to 2016 (compared with the 1990-99 average), with no clear upward or downward trend in the lethality of these extreme events.

change threatens to undermine the past 50 years of gains in public health, and conversely, that a comprehensive response to climate change could be "the greatest global health opportunity of the 21st century".

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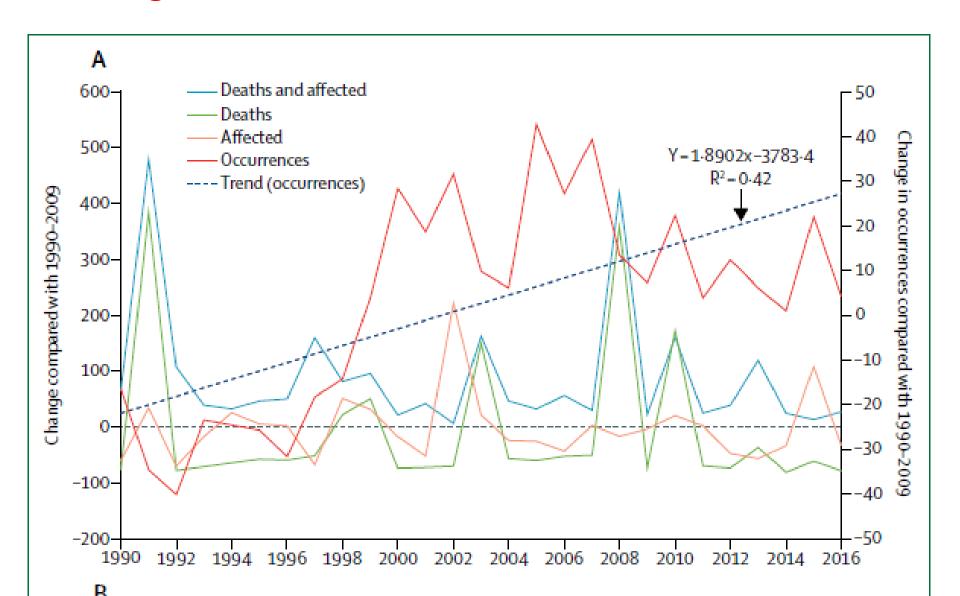
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### Change in Weather-Related Disasters (vs. 1990-99 average) Droughts, Extreme Heatwaves, Floods, Storms, Wildfires



### **Increasing and Devastating Wildfires**





Just like life, nature is unpredictable. Unfortunately, Californians experienced this in the worst way possible on November 9. Even the coming together of families on Thanksgiving



### Increasing Weather-Related Disasters by Geographic Region

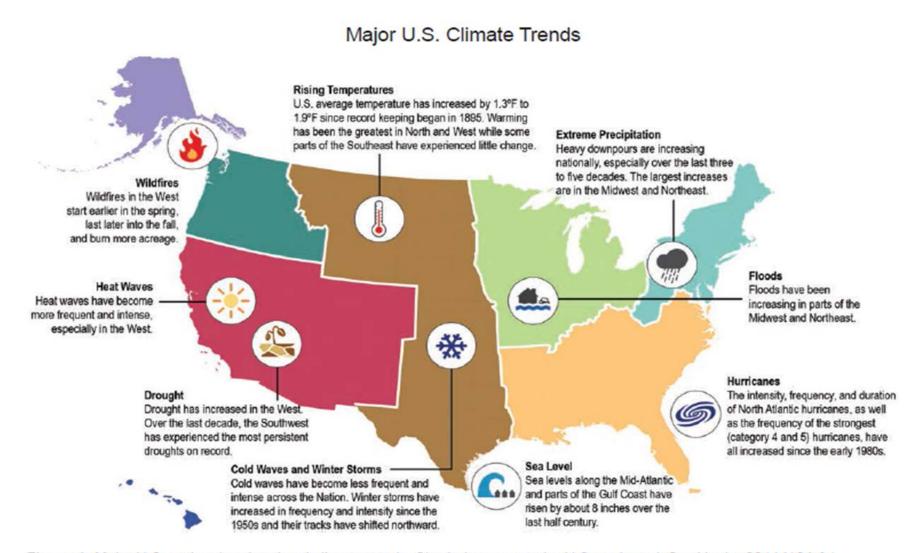
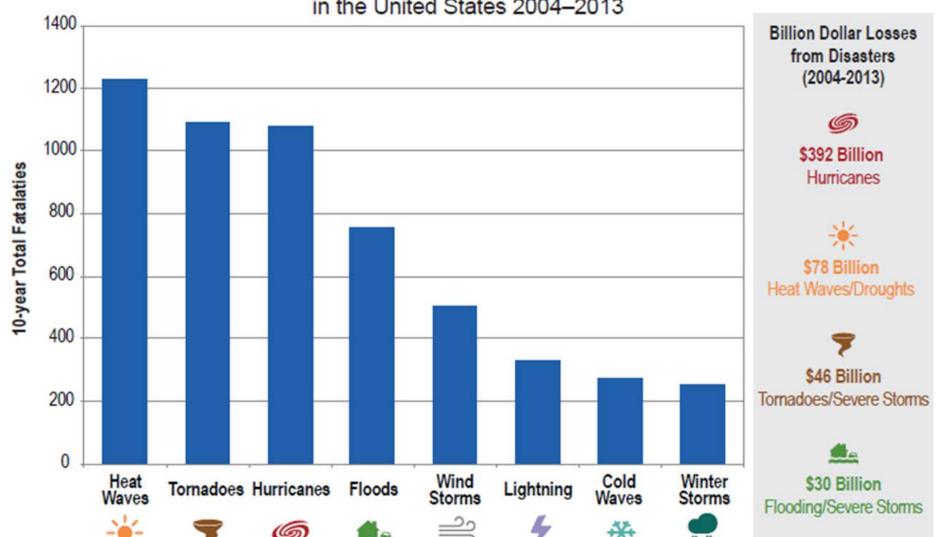


Figure 1: Major U.S. national and regional climate trends. Shaded areas are the U.S. regions defined in the 2014 NCA.24

### Deaths and Billion Dollar Losses from Extreme Events United States: 2004 to 2018

Estimated Deaths and Billion Dollar Losses from Extreme Events in the United States 2004–2013





Nick Watts, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, Wenjia Cai, Diarmid Campbell-Lendrum, Jonathan Chambers, Peter M Cox, Meaghan Daly, Niheer Dasandi, Michael Davies, Michael Depledge, Anneliese Depoux, Paula Dominguez-Salas, Paul Drummond, Paul Ekins, Antoine Flahault, Howard Frumkin, Lucien Georgeson, Mostafa Ghanei, Delia Grace, Hilary Graham, Rébecca Grojsman, Andy Haines, Ian Hamilton, Stella Hartinger, Anne Johnson, Ilan Kelman, Gregor Kiesewetter,

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### **Indicator 1.5:**

Global health initiatives have improved the health profile of populations around the world—a trend that unmitigated climate change is expected to undermine.

Change,<sup>2</sup> which concluded that anthropogenic climate change threatens to undermine the past 50 years of gains in public health, and conversely, that a comprehensive response to climate change could be "the greatest global health opportunity of the 21st century".

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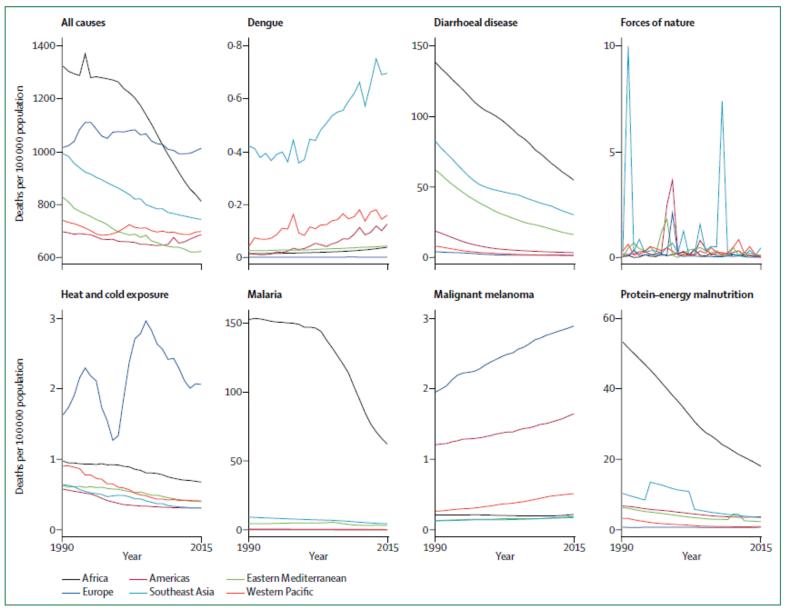
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### Trends in Mortality from Selected Causes of Death Global Burden of Disease Study 2015





Nick Watts, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, Wenjia Cai, Diarmid Campbell-Lendrum, Jonathan Chambers, Peter M Cox, Meaghan Daly, Niheer Dasandi, Michael Davies, Michael Depledge, Anneliese Depoux, Paula Dominguez-Salas, Paul Drummond, Paul Ekins, Antoine Flahault, Howard Frumkin, Lucien Georgeson, Mostafa Ghanei,

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in public health,

### Indicator 1.6:

Climate trends have led to a global increase in the vectorial capacity for the transmission of dengue from *A aegypti* and *Aedes albopictus* of 3.0% and 5.9% compared with 1990 levels and 9.4% and 11.1%, respectively, compared with 1950 levels.

response to climate change could be "the greatest global health opportunity of the 21st century".

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### Average Annual Vectorial Capacity for Dengue in *Aedes* aegypti and *Aedes albopictus* Aedes-positive Countries

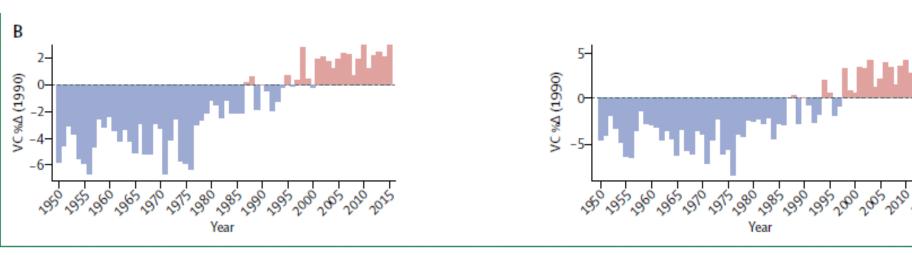


Figure 9: Average annual vectorial capacity (VC) for dengue in Aedes aegypti and Aedes albopictus for selected Aedes-positive countries

### UTAH has Just Joined the Aedes aegypti Club!

Local New Report, September 13, 2019

### Yellow fever mosquito invades southeast Utah

Aggressive bloodsucker loves to bite people

By Amy Joi O'Donoghue | @Amyjoi16 | Sep 13, 2019, 3:07pm MDT









An aggressive mosquito that hides out in children's toy trucks and wheelbarrows has invaded southeast Utah and it loves to bite people. | Adobe Stock

MOAB — An aggressive mosquito that hides out in children's toy trucks and wheelbarrows has invaded southeast Utah and it loves to bite people.

What's worse is that it is an efficient carrier of viruses that include yellow fever, dengue fever, Zika and the extremely rare chikungunya virus.

The detection of the invasive Aedes aegypti mosquitoes in the Moab area provoked a rapid, extensive and aggressive attack Wednesday and Thursday involving not only the Moab Mosquito Abatement District, but supporting crews from four northern Utah area districts: Davis, Topele Valley, South Salt Lake and Salt Lake City.

#### **Most Read**



Supreme Court Justice Gorsuch at BYU: 'Nine people in Washington should not govern'



'AGT': Utah native Kodi Lee won't receive \$1 million for winning. Here's why



### Eastern Equine Encephalitis—Another Growing and Lethal Mosquito-transmitted Disease

## Increase in Tick-Borne Disease 2001 to 2014: Lyme Disease—a Cause of Chronic Arthritis and Heart Disease



Nick Watts, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, Wenjia Cai,
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### **Indicator 1.7:**

Climate change increases vulnerability to undernutrition: The number of undernourished people in the 30 most vulnerable countries has increased from 298 million people in 1990 to 422 million people in 2016. Further, fish consumption is decreasing, another indication of food insecurity.

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### **Vulnerability to Undernutrition and Climate Change**

- Regions with highest vulnerability to undernutrition (i.e., Africa and Southern Asia) are also where yield losses due to climate warming will be the greatest, increasing the vulnerability of these populations to the health consequences of undernutrition. High dependence on one crop increases vulnerability further. For example, Kenya, with a domestic production dependency for cereals of almost 80%, is 69% dependent on maize, is experiencing high levels of undernutrition, and is particularly vulnerable to climate-related yield losses.
- Decreasing fish consumption is an indication of food insecurity, especially in local shoreline communities that depend on marine sources for food. These communities are especially vulnerable to any decreases in fish stocks. This is particularly concerning for the 1 billion people who rely on fish as their principal source of protein, placing them at increased risk of malnutrition. Increasing water temperatures pose grave threats (e.g., toxic algal blooms).

## Water Pollution

### Associated Press

Fri 22 Jul 2016

### Huge toxic algae bloom sickens more than 100 in Utah amid heatwave

Bacteria has spread rapidly to cover almost all of Utah Lake, turning the water bright green with a pea soup texture and leaving scummy foam along the shore



▲ Utah poison control has fielded hundreds of calls related to the bloom, including 130 involving people who have reported vomiting, diarrhea, headache and rashes. Photograph: Rick Egan/AP

A huge toxic algae bloom in <u>Utah</u> has closed one of the largest freshwater lakes west of the Mississippi river, sickening more than 100 people and leaving farmers scrambling for clean water during some of the hottest days of the year.





Nick Watts, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, Wenjia Cai, Diarmid Campbell-Lendrum, Jonathan Chambers, Peter M Cox, Meaghan Daly, Niheer Dasandi, Michael Davies, Michael Depledge, Anneliese Depoux, Paula Dominguez-Salas, Paul Drummond, Paul Ekins, Antoine Flahault, Howard Frumkin, Lucien Georgeson, Mostafa Ghanei, Delia Grace, Hilary Graham, Rébecca Groisman, Andy Haines, Ian Hamilton, Stella Hartinger, Anne Johnson, Ilan Kelman, Gregor Kiesewetter

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### **Indicator 1.8:**

Climate change is a major and increasing factor in migration and population displacement. The total number of people vulnerable to migration might increase to 1 billion by the end of the century without significant further action on climate change.

in public health, and conversely, that a comprehensive response to climate change could be "the greatest global health opportunity of the 21st century".

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### **Climate-Induced Impact on Migration**

- Climate change-induced migration can occur through a variety of social and political pathways, ranging from sea level rise and coastal erosion to changes in precipitation and temperature that reduce the arability of land and exacerbate food and water supplies (e.g., migrants to our southern border). Estimates of future climate change migrants vary widely, but range from 25 million people to 1 billion people by 2050.
- In the long term, human exposure and vulnerability to ice sheet collapse is increasing as the number of people living close to the coast and at elevations close to sea level increases. With 2000 as a baseline, the population living below 10 m above sea level will increase from 634 million people to 1005–1091 million people by 2050. From 2100 and beyond, without mitigation and adaptation interventions, more than 1 billion people might need to migrate because of sea level rise caused by ice sheet collapse.

# The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health



Nick Watts, Markus Amann, Sopia Augh Kadesop, Kristing Palasona, Timothy Paylor, Mayayall Paykoff, Patas Pyass Wapiia Cai

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#### Executive sum

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### Indicator 3.5:

Air pollutants directly harmful to health are emitted by combustion processes that also contribute to emissions of greenhouse gas. As such, well designed actions to reduce greenhouse gas emissions will improve ambient air quality and result in improvements in human health.

This indicator reports that 71% of the 2971 cities in WHO's database do not satisfy WHO annual fine particulate matter exposure recommendations.

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# Annual Fine Particulate Matter (PM<sub>2.5</sub>) vs. Per Capita Gross Domestic Product in 246 Cities Worldwide

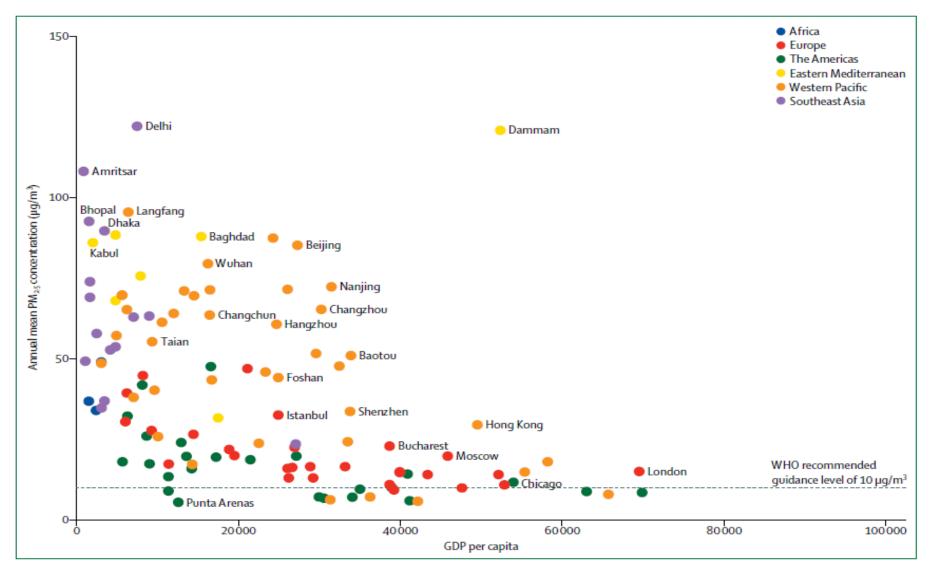


Figure 21: Annual mean fine particulate matter (PM<sub>2.5</sub>) concentration versus per capita gross domestic product (GDP) for 246 cities in the Sustainable Healthy Urban Environments database

## Selected Air Pollutants and their Sources Globally in 2015

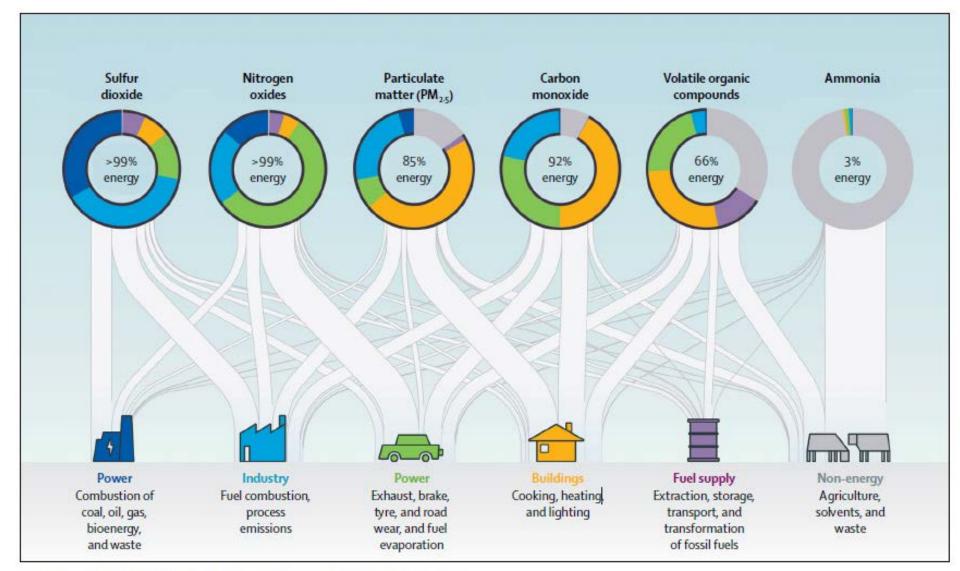
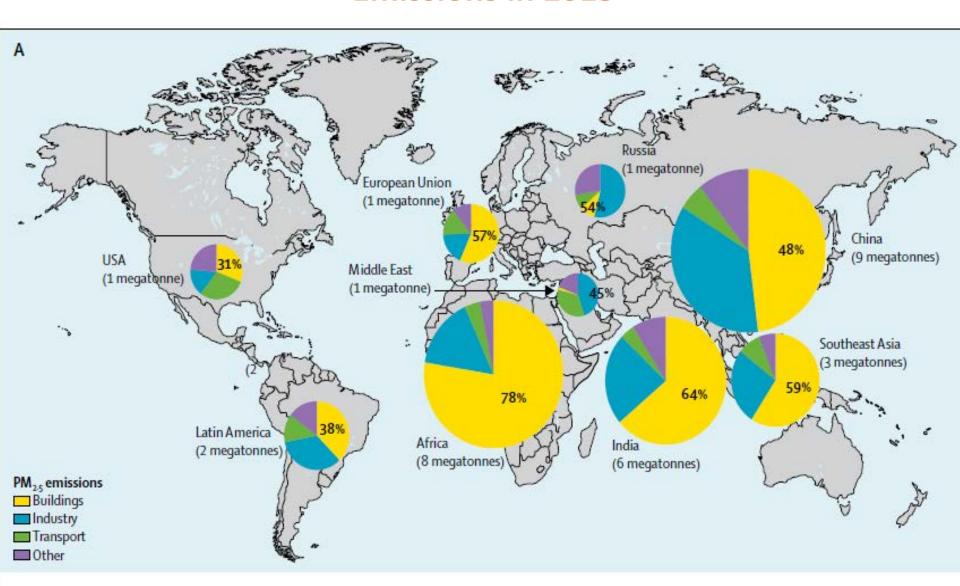


Figure 22: Selected primary air pollutants and their sources globally in 2015

Adapted from the World Energy Outlook Special Report: Energy and Air Pollution, 103 by permission of OECD and International Energy Agency Publishing.

## **Energy-related Emission of Fine Particulate Matter (PM<sub>2.5</sub>)**

**Emissions in 2015** 



## **Premature Mortality from Ambient Air Pollution**

Long-term exposure to ambient PM<sub>2.5</sub> is associated with increased mortality and morbidity from cardiovascular and pulmonary diseases. WHO estimated that ambient air pollution causes about 3 million premature deaths worldwide every year. The sources of air pollution and greenhouse gases are overlapping, so greenhouse gas mitigation measures can have large co-benefits for human health.



## Air Pollution: Smog Dome over Salt Lake City





For every 10-µg/m³ increase in fine particulate matter air pollution, there was a 15% increase in the risk of a major heart attack that day

## Short-Term Elevation of Fine Particulate Matter Air Pollution and Acute Lower Respiratory Infection

Benjamin D. Horne , Elizabeth A. Joy , Michelle G. Hofmann , Per H. Gesteland , John B. Cannon , Jacob S. Lefler , Denitza P. Blagev , E. Kent Korgenski , Natalie Torosyan , Grant I. Hansen , David Kartchner , and Show All... <a href="https://doi.org/10.1164/rccm.201709-1883OC">https://doi.org/10.1164/rccm.201709-1883OC</a> PubMed: 29652174

"Conclusions: In this large sample of urban/suburban patients, short-term exposure to elevated PM<sub>2.5</sub> air pollution was associated with greater healthcare use for ALRI in young children, older children, and adults."



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VOL. 381 NO. 8

### Ambient Particulate Air Pollution and Daily Mortality in 652 Cities

C. Liu, R. Chen, F. Sera, A.M. Vicedo-Cabrera, Y. Guo, S. Tong, M.S.Z.S. Coelho, P.H.N. Saldiva, E. Lavigne, P. Matus, N. Valdes Ortega, S. Osorio Garcia, M. Pascal, M. Stafoggia, M. Scortichini, M. Hashizume, Y. Honda, M. Hurtado-Díaz, J. Cruz, B. Nunes, J.P. Teixeira, H. Kim, A. Tobias, C. Íñiguez, B. Forsberg, C. Åström, M.S. Ragettli, Y.-L. Guo, B.-Y. Chen, M.L. Bell, C.Y. Wright, N. Scovronick, R.M. Garland, A. Milojevic, J. Kyselý, A. Urban, H. Orru, E. Indermitte, J.J.K. Jaakkola, N.R.I. Ryti, K. Katsouyanni, A. Analitis, A. Zanobetti, J. Schwartz, J. Chen, T. Wu, A. Cohen, A. Gasparrini, and H. Kan

#### BACKGROUND

The systematic ev by differences in

#### METHODS

We evaluated the diameter of 10  $\mu$  or less (PM<sub>2.5</sub>) wit ple countries or recities in 24 countries and om-effects me

"Our data show independent associations between short-term exposure to PM<sub>10</sub> and PM<sub>2.5</sub> and daily all-cause, cardiovascular, and respiratory mortality in more than 600 cities across the globe. These data reinforce the evidence of a link between mortality and PM concentration established in regional and local studies"

academic delisted in the equests to Dr. ong-An Road, or at kanh@

rs. Gasparrini to this article.

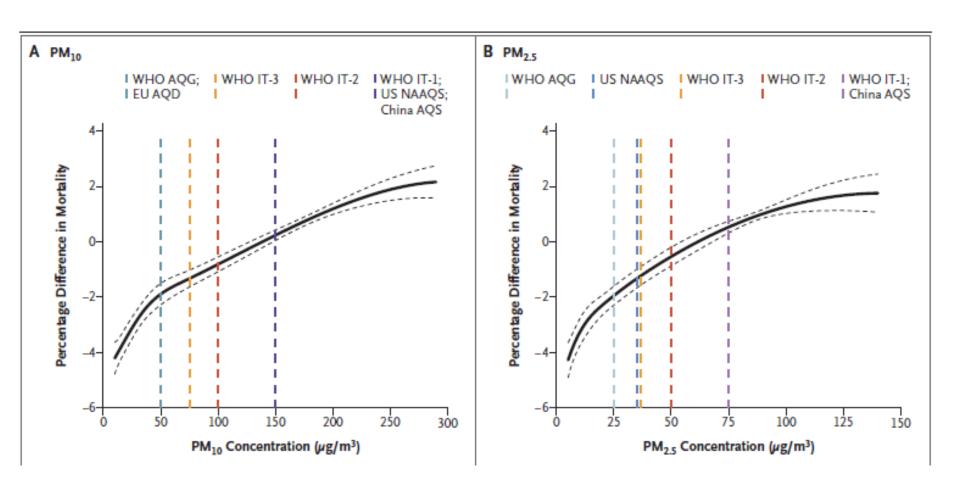
64

ats Medical Society.



## Pooled Concentration—Response Curves for the Associations of PM<sub>10</sub> (Panel A) and PM<sub>2.5</sub> (Panel B) with Daily All-Cause Mortality

The NEW ENGLAND JOURNAL of MEDICINE



# The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health



Nick Watts, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, Wenjia Cai, Diarmid Campbell-Lendrum, Jonathan Chambers, Peter M Cox, Meaghan Daly, Niheer Dasandi, Michael Davies, Michael Depledge, Anneliese Depoux, Paula Dominquez-Salas, Paul Drummond, Paul Ekins, Antoine Flahault, Howard Frumkin, Lucien Georgeson, Mostafa Ghanei,

Delia Grace, Hilary Gra Dominic Kniveton, I Ali Mohammad La David Pencheon, St

#### Executive sur

Rebecca Steinbach.

The Lancet Co climate change ment of the implementation implications of of the 2015 Lan Change,<sup>2</sup> which change threatens

**Indicator 3.6:** 

Trends in clean fuel for transport: Transport fuel use on a per-capita basis has increased worldwide by almost 24% since 1990. Petrol and diesel continue to dominate, but use of non-conventional fuels has been rapidly expanding, with more than 2 million electric vehicles sold between 2010 and 2017.

in public health, and conversely, that a comprehensive response to climate change could be "the greatest global health opportunity of the 21st century".

The Lancet Countdown is a collaboration between

adaptation will become insufficient in the future. The total value of economic losses resulting from climate-related events has been increasing since 1990, totalling LIS\$120 billion in 2016, 90% of these economic losses in

t 2018; 391: 581-630

hed Online er 30, 2017

/dx.doi.org/10.1016/ )-6736(17)32464-9

nline for <mark>infographic</mark>

nline publication has been ted. The corrected version ppeared at thelancet.com ovember 23, 2017

\*Co-chairs

Institute of Global Health (N Watts MBBS, N Wheeler MSc), UCL Energy Institute (I Chambers PhD.

# Per-Capita Fuel Use by Type for Transport Sector (left) Cumulative Electric Vehicle Sales Worldwide (right)

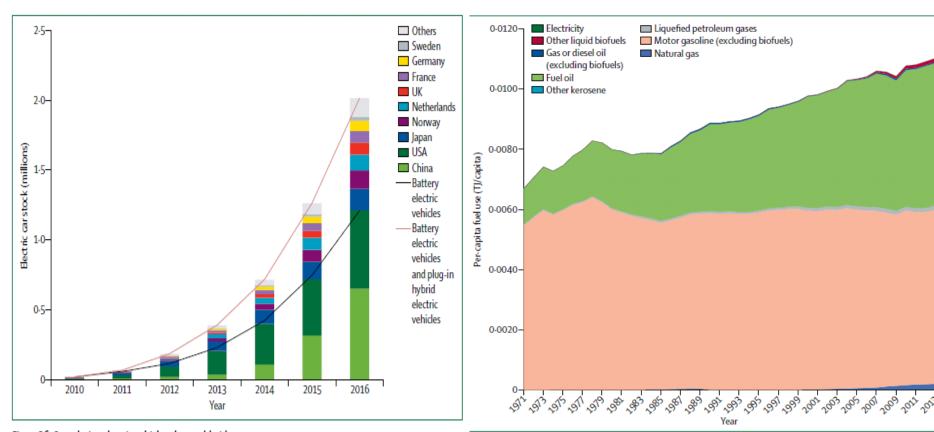


Figure 26: Cumulative electric vehicle sales worldwide

Adapted from The Global EV Outloook 2017, DS D6 by permission of OECD and International Energy Agency Publishing.

*Igure* 25: Per-capita fuel use by type for transport sector with all fuels

### **Modes of Transportation in Selected World Cities**

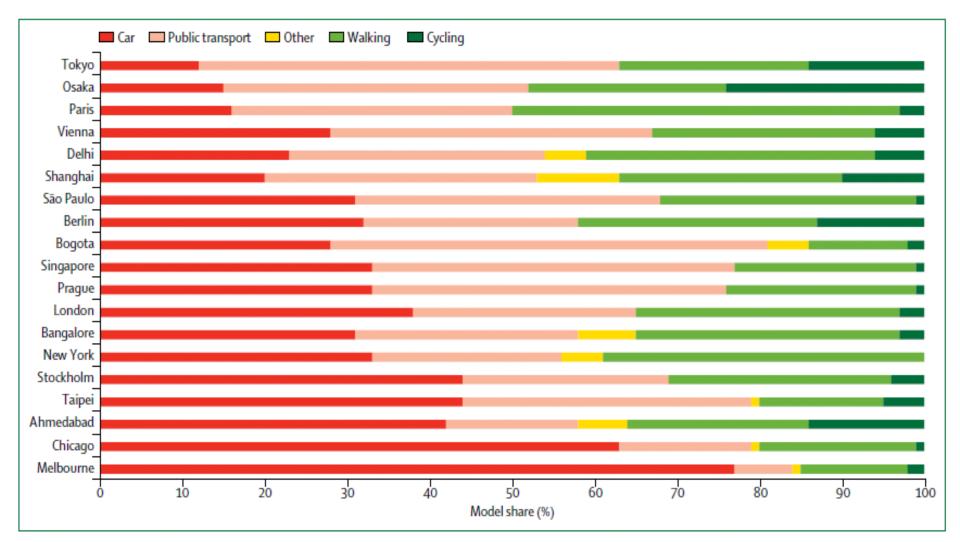


Figure 27: Modal shares in world cities

Other typically includes paratransit (transport for people with disabilities), electric bikes, or both.

# Government and Industry Can be Leaders in Conversion to Clean Energy Transportation

# Progress Is Being Made on 7 of the 10 Lancet 2015 Countdown Recommendations

- 1) Invest in climate change and public health research
- 2) Scale-up financing for climate-resilient health systems
- 3) Phase-out coal-fired power
- 4) Encourage a city-level low-carbon transition to reduce urban pollution
- 5) Rapidly expand access to renewable energy, unlocking the substantial economic gains available from this transition
- 6) Agree and implement an international treaty that facilitates the transition to a low-carbon economy
- 7) Develop a new, independent collaboration to provide expertise in implementing policies that mitigate climate change and promote public health, and to monitor progress over the next 15 years.



# Citizens' Climate Lobby: Working on a Solution—One Example





## Citizens' Climate Lobby: Core Values

Citizens' Climate Lobby is a non-profit, nonpartisan, grassroots advocacy organization focused on national policies to address climate change. These core values guide our staff and volunteers along the way.

**FOCUS:** We are focused on what we see as the single most impactful solution to climate change — a national carbon fee and dividend.

**OPTIMISM**: We believe that people are good, and that democracy works.

**RELATIONSHIPS**: We take the most generous approach to other people as possible — appreciation, gratitude, and respect.

**INTEGRITY:** We are prepared and do our research. Our approach is thoughtful & thorough. We are on time to our meetings.

**PERSONAL POWER:** We use our voices to be heard.

**BEING NON-PARTISAN:** Our group is open to all who are serious about solving climate change.





### **Carbon Fee and Dividend**

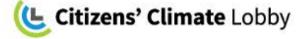
### The best first step

Place a fee on fossil fuels at the source (mine, well or port).

Return all of the revenue to households equally.

A border adjustment on goods imported from or exported to countries without an equivalent price on carbon.





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# Thanks! **Questions?**



