

# RED and GREEN

How a green milieu benefits  
to cardiovascular health

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CHU Montreal and CS Laval

Associate Professor of Medicine

Faculty of Medicine

Department of Environmental Health

University of Montreal



Dr François Reeves

# PLANÈTE Cœur

Santé cardiaque et environnement



 Éditions du  
CHU Sainte-Justine

ÉDITIONS  
MULTIMONDES

Université   
de Montréal

*"Planet Heart is the world seen through 'the eyes of the heart.' That cardiovascular health depends on the environment has never been so clearly shown."*

DAVID SUZUKI

FRANÇOIS REEVES, MD

# planet HEART

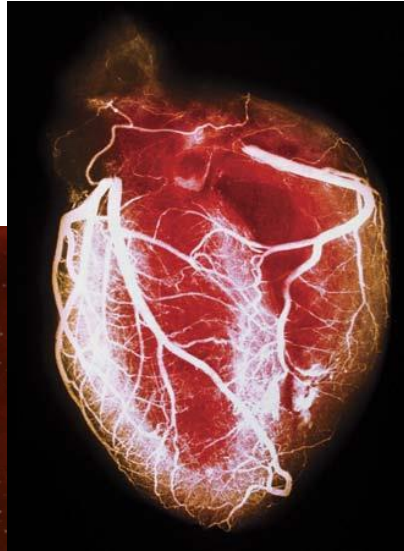
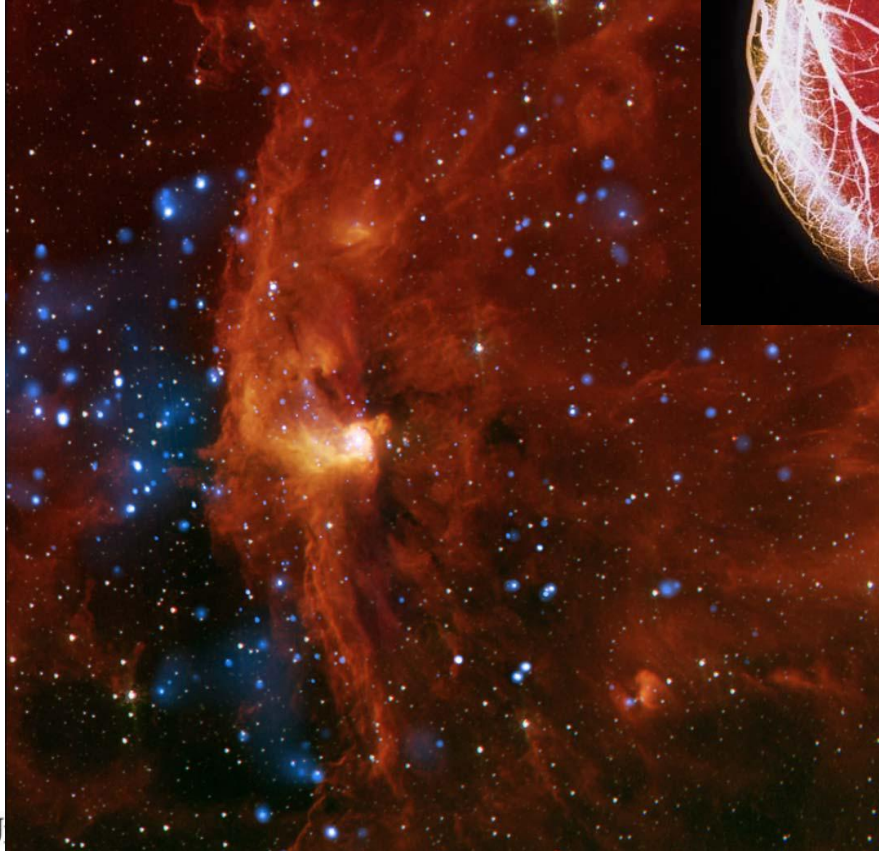
HOW AN  
UNHEALTHY ENVIRONMENT  
LEADS TO  
HEART DISEASE

Greystone Books



# Oxygen

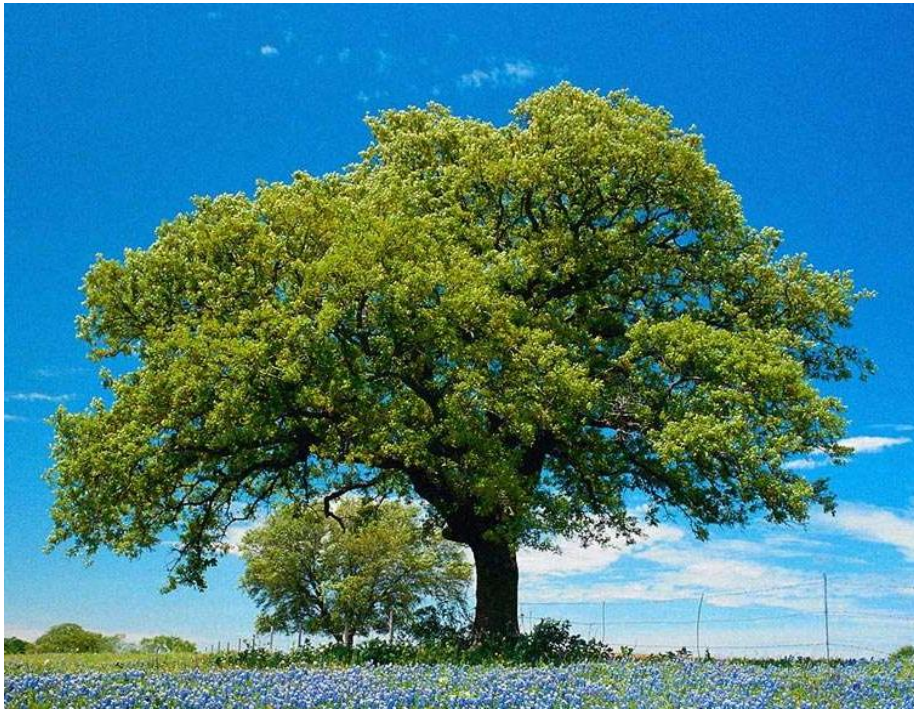
Blue Giants



Green Giants







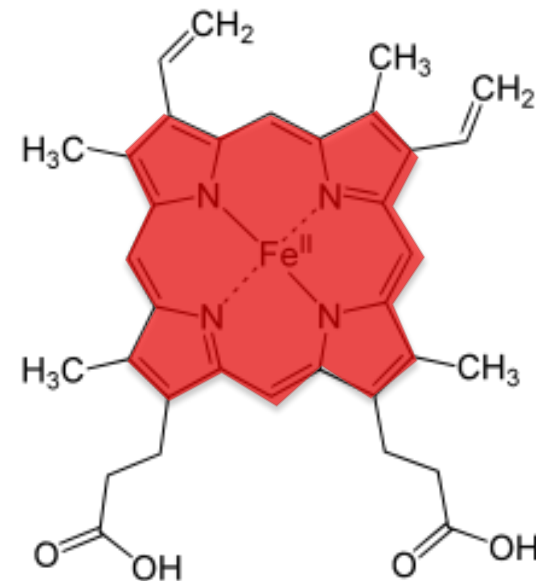
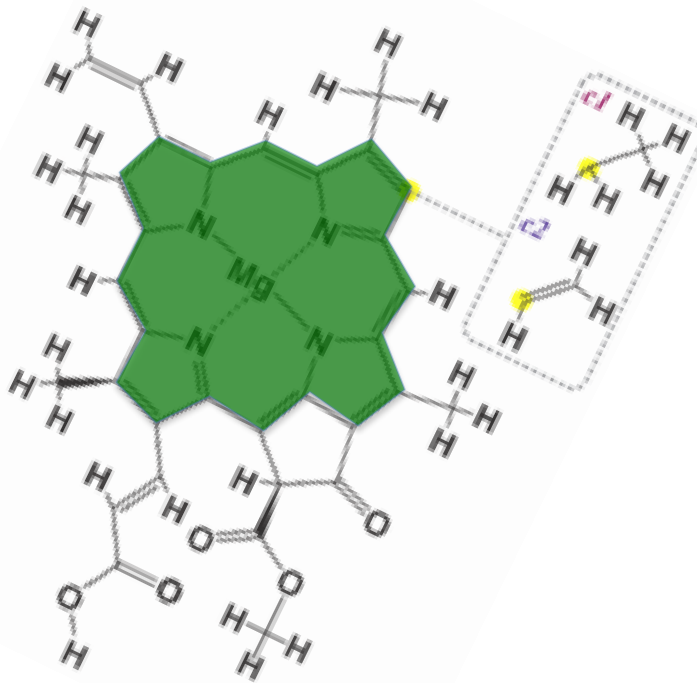


# 600 M Years ago

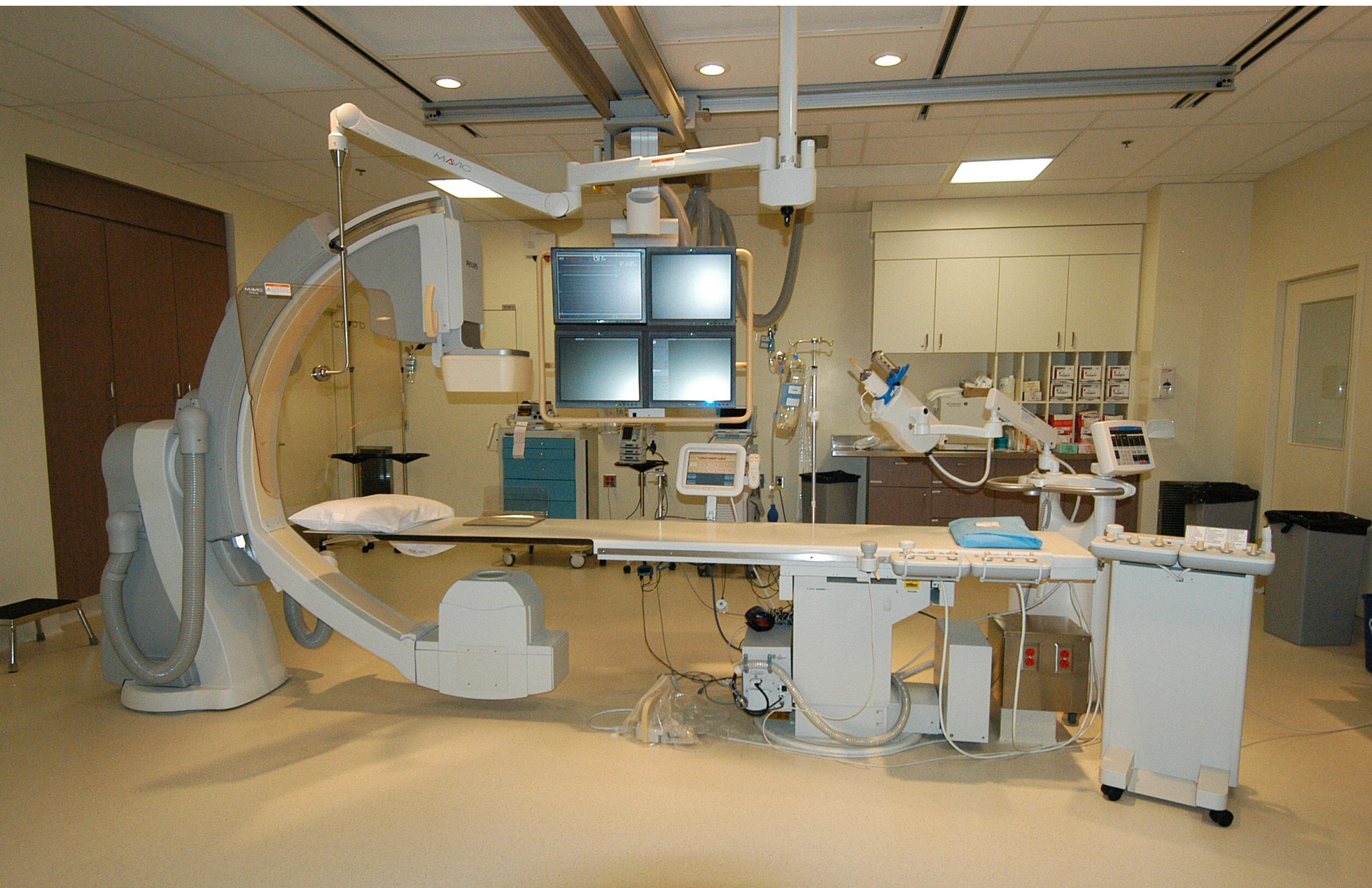
## Differentiation vegetal/animal

Chlorophyll

Hemoglobin





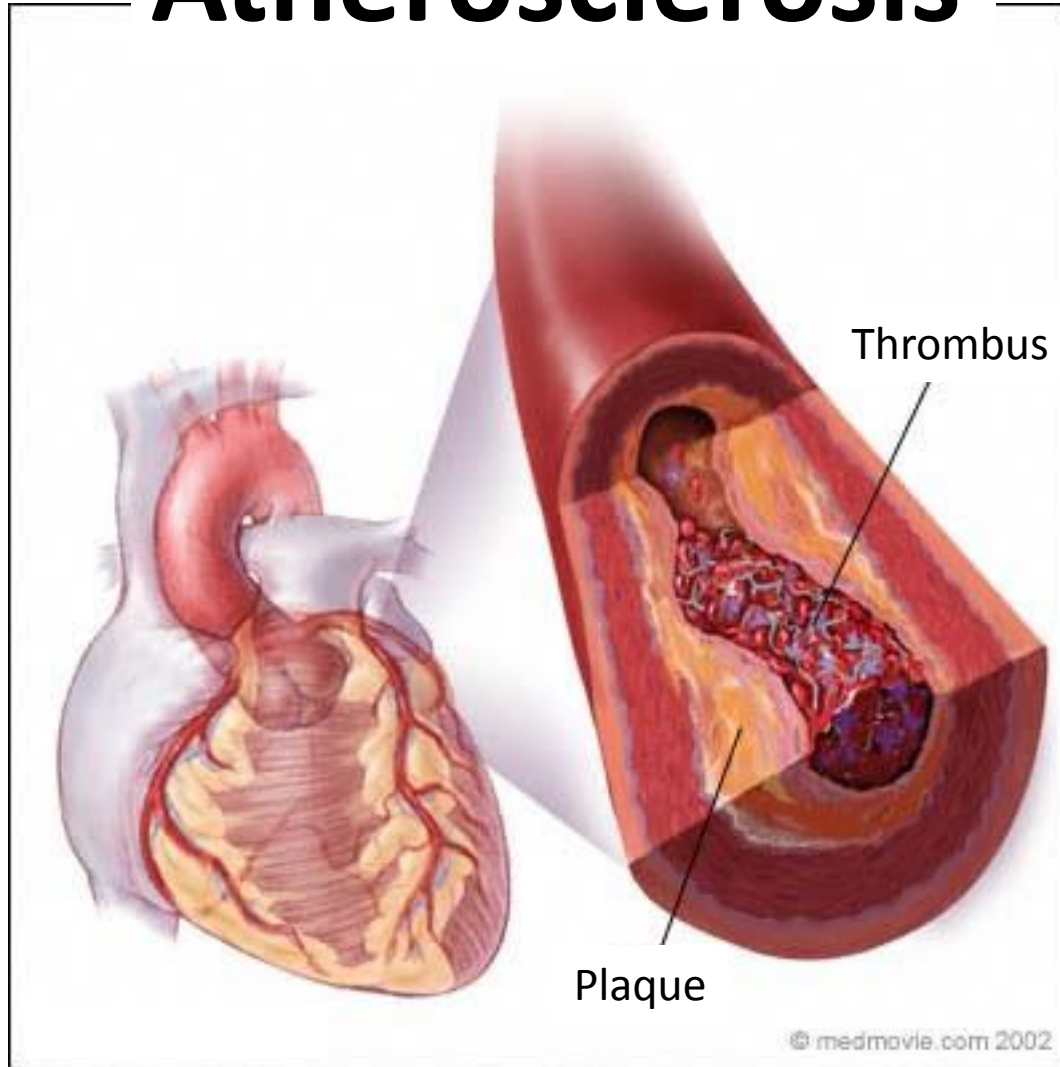








# Atherosclerosis



# Why Cardiovascular disease?

- Framingham Heart Study 1948-ongoing

National Heart, Lung and Blood Institute /Boston University

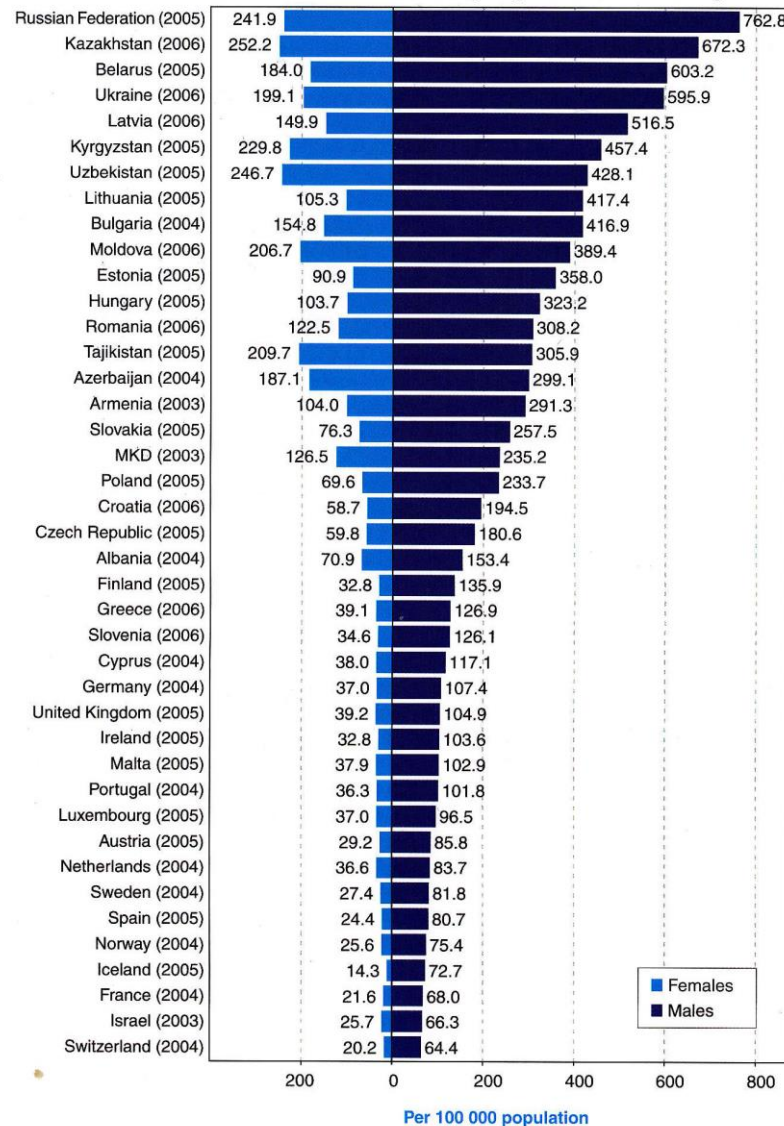
- Heredity
- Diabetes
- Tobacco
- High cholesterol
- High blood pressure
- Sedentarity
- Obesity
- Stress





Did Framingham  
say everything ?



Deaths from diseases  
of the circulatory system, 25–64 years

Russia

Hungary

Poland

Germany

Austria

Switzerland

750

500

400

300

200

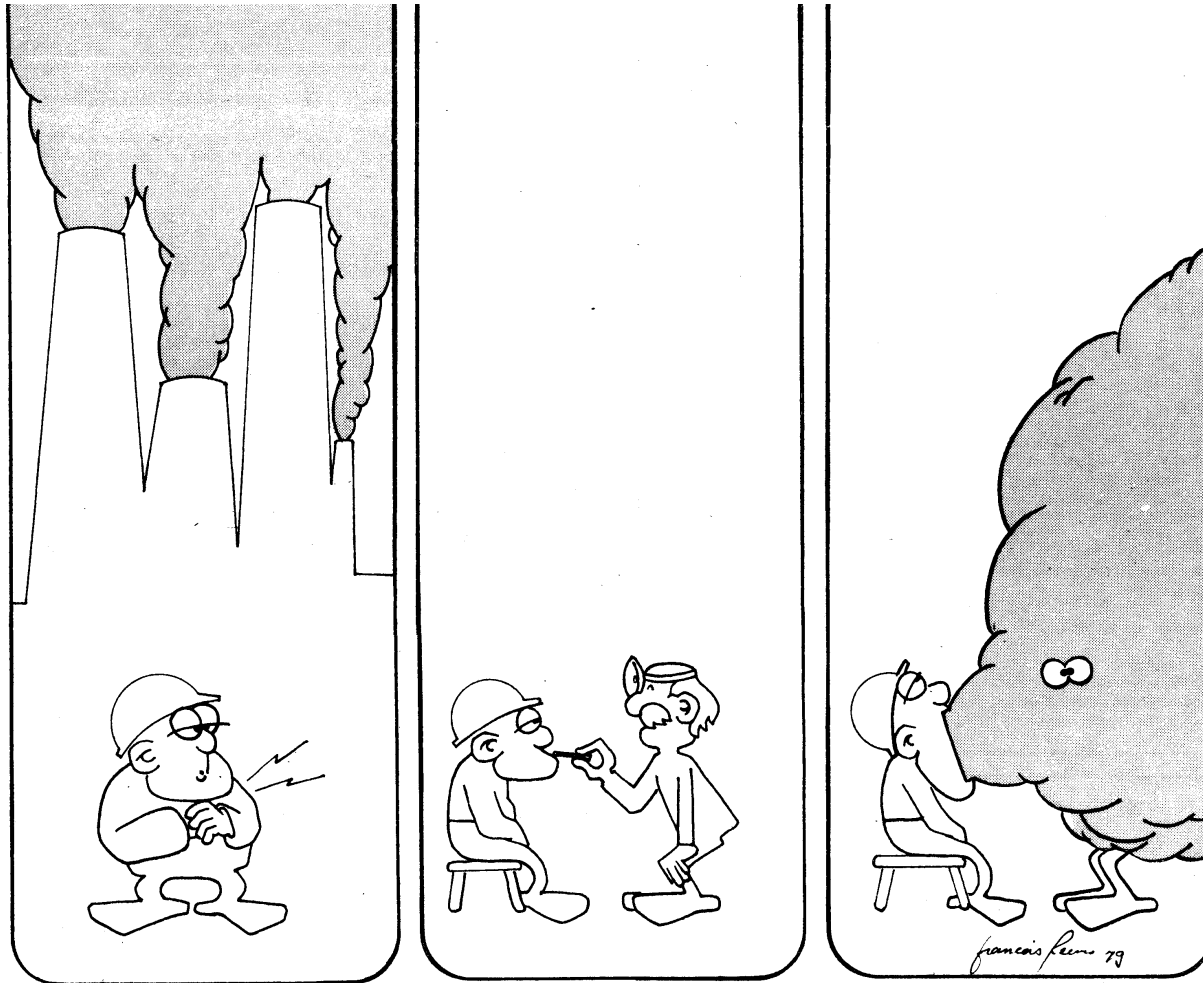
100

60





# Cardiology is an environmental specialty





# Cardiovascular Disease: Facts

- Rare in animals
- Rare within Mankind
  - before industrial revolution
- Rare within Mankind
  - living outside industrialized world



# Cardiovascular Disease: Facts

- Inducible in animals
  - Excellent medical bench test
- Dramatic increase of cardiac morbidity
  - Following traditional industrial revolution





# Why Framingham? 1948

## The Framingham Heart Study

little was known about the general causes of heart disease and stroke, but the death rates for cardiovascular disease have been increasing steadily since the beginning of the century and had become an American epidemic.



# Why Framingham? 1948

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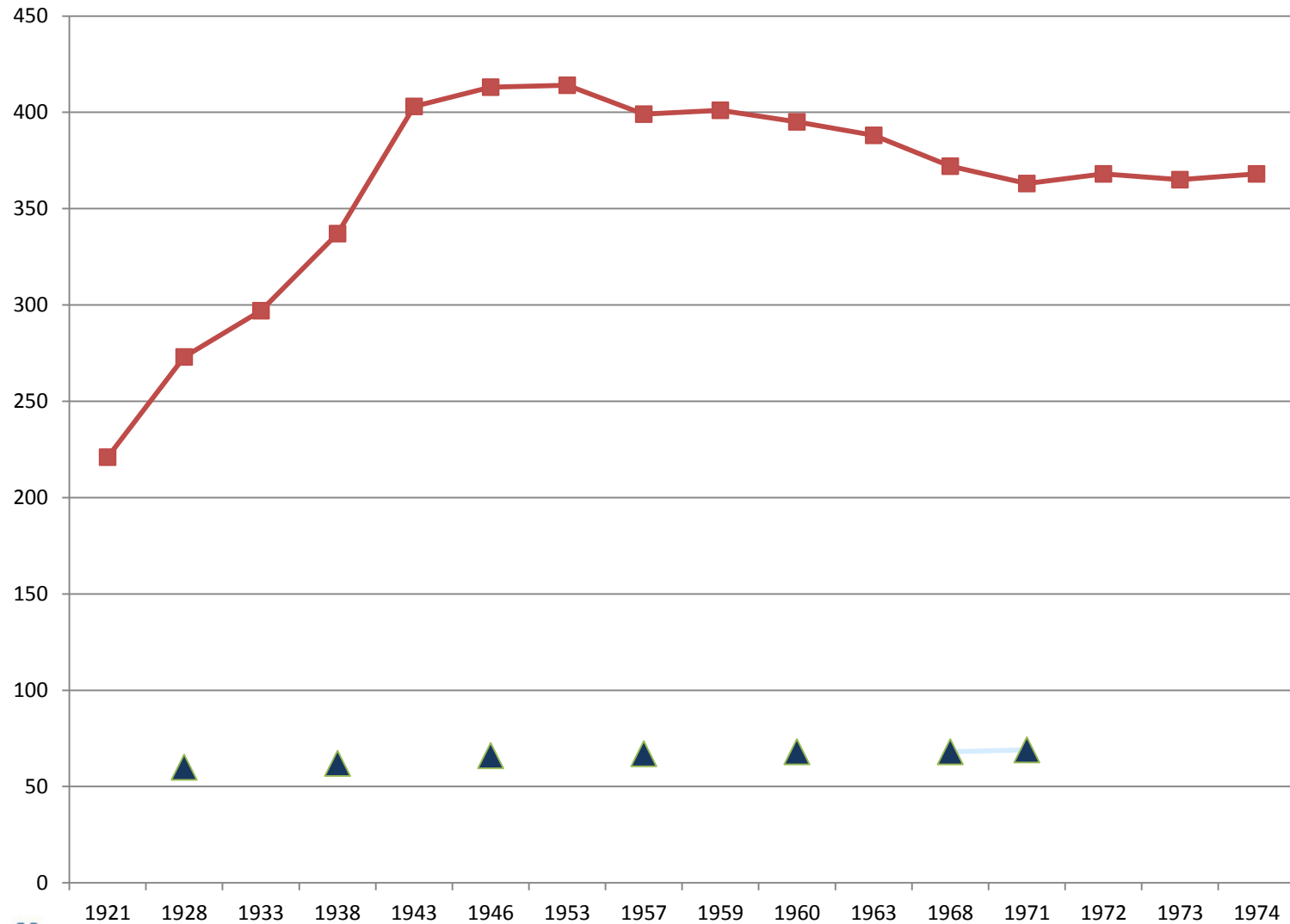
The Framingham Heart Study

American epidemic





# Rate of CV mortality/ Life expectancy Canada 1920-1975



# Why Atherosclerosis ?

## *3 triads*

### – What we are

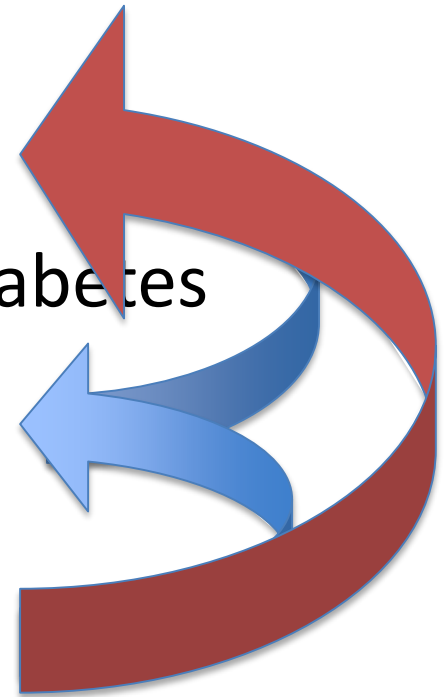
- Cholesterol, hypertension, diabetes

### – What we do

- Sedentarity, obesity, tobacco

### – Where we are

- Environment, food, urbanism





# Human trade with environment

- What we eat • 1 kg
- What we drink • 2 kgs
- What we breathe • 10-20 kgs



# Industrial Revolution: Vascular Nano-Aggressors

- Food Nano-Aggressors
  - Salt in excess
  - Added industrial sugars
  - Trans fat
  - Phosphoric acid
  - Pesticides
- Airborne Nano-Aggressors
  - CO, NO<sub>2</sub>, SO<sub>2</sub>
  - Fine, Ultrafine Particles
  - VOC, PAH
  - Ozone
  - Lead, Mercury



**"People are fed by  
the FOOD industry, which  
pays no attention to HEALTH..."**

**And are treated by  
the HEALTH industry,  
which pays no attention to FOOD."**

facebook.com/theorganicindian  
**Wendell Berry**





# United States

## THE REVISES

The North Carolina family fights the effects of abundance with exercise

### GRAINS AND OTHER STARCHY FOODS

\$17.92

### DAIRY

\$14.51

### MEAT, FISH AND EGGS

\$54.92

### FRUITS AND VEGETABLES

\$41.07

### CONDIMENTS

\$12.51

### SNACKS AND DESSERTS

\$21.27

### PREPARED FOOD

\$24.27

### FAST FOOD

\$71.61

### RESTAURANTS

\$6.15

### BEVERAGES

\$77.75

### FOOD EXPENDITURE FOR THE WEEK

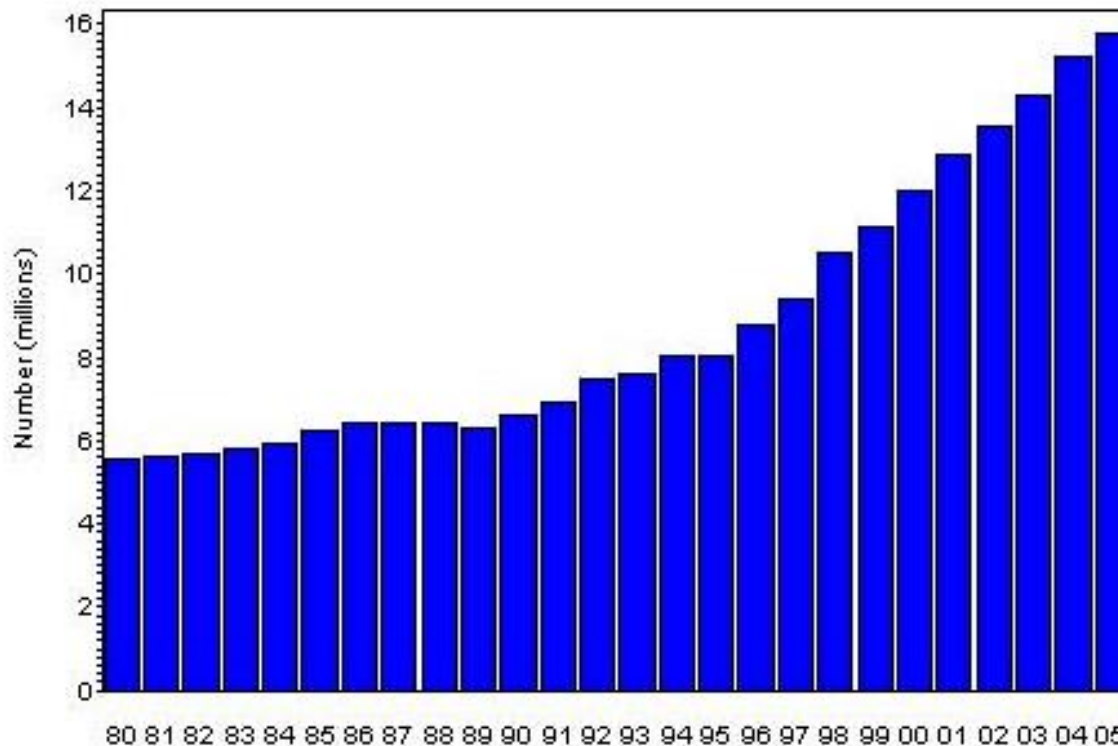
\$341.98



# Collateral damage of obesity/metabolic syndrome: Explosion of diabetes

## Number (in Millions) of Persons with Diagnosed Diabetes, United States, 1980–2005

Diabetes is becoming more common in the United States. From 1980 through 2005, the number of Americans with diabetes increased from 5.6 million to 15.8 million. As the detailed tables show, people aged 65 years or older account for approximately 38% of the population with diabetes.



2014: 29 M



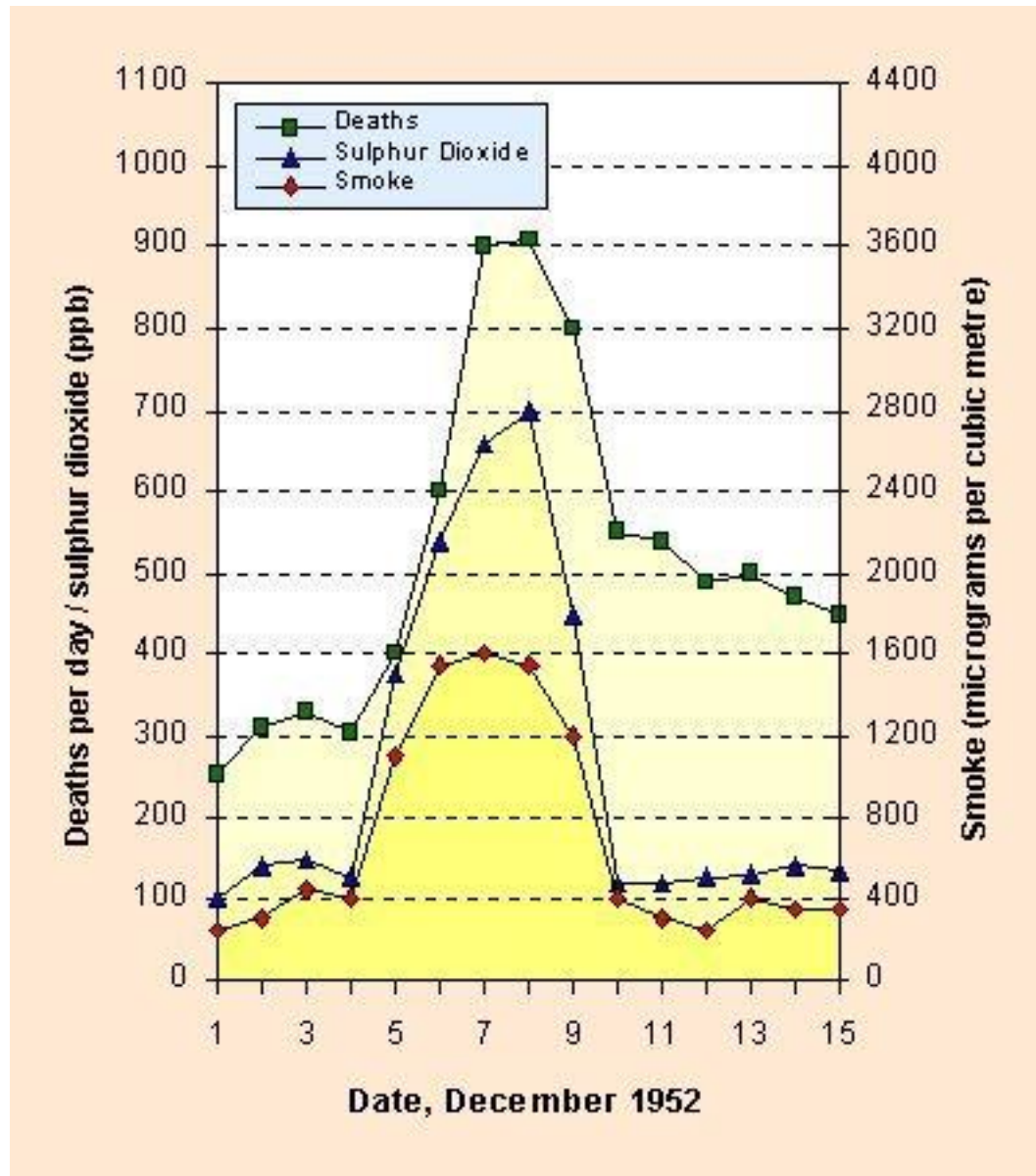


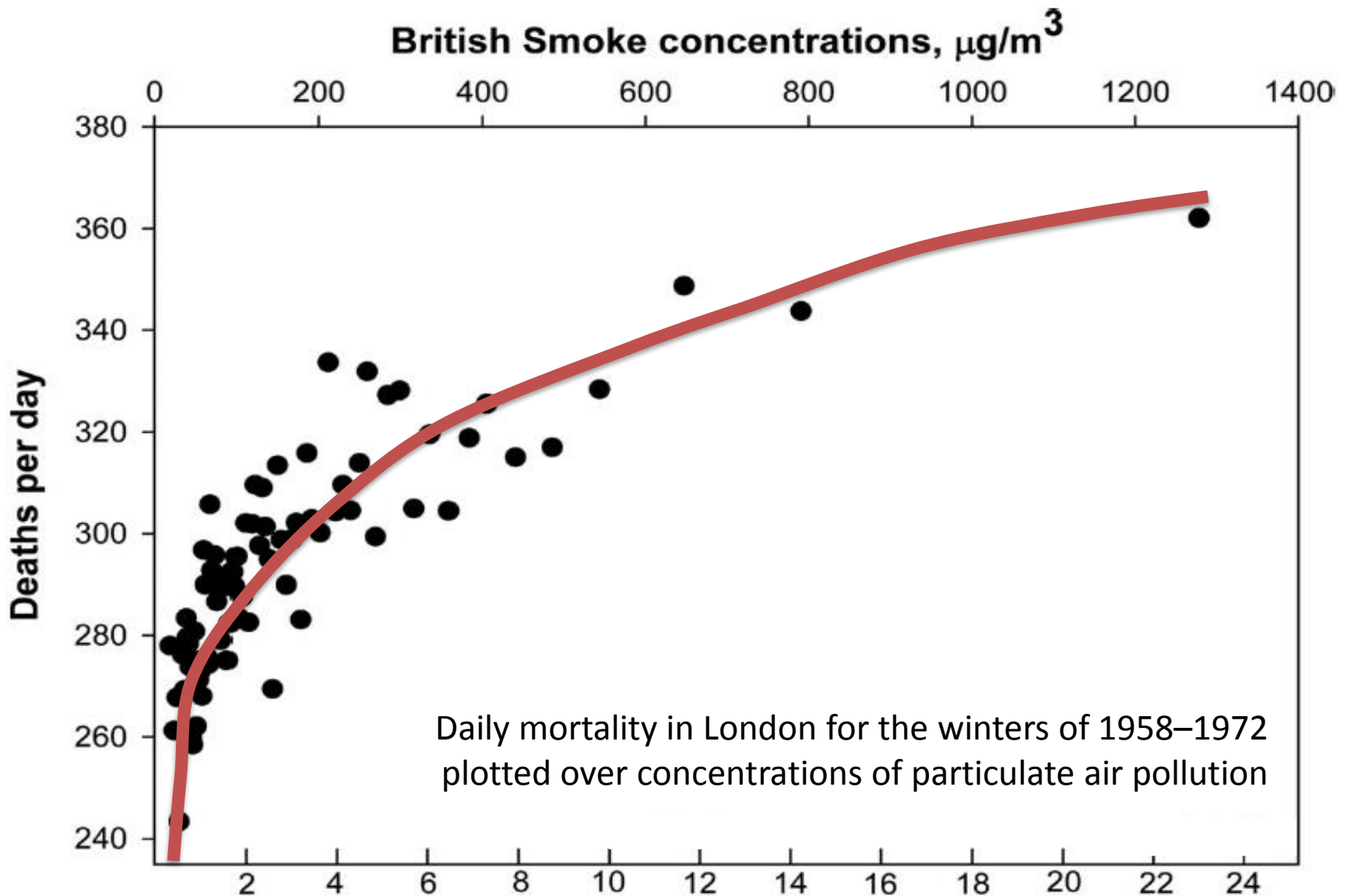
# 1952: the Great London Smog





# "Great London Smog » : 12 000 deaths in excess





*Circulation September 15, 2009*

# 1993: The Six-Cities Study

## The New England Journal of Medicine

©Copyright, 1993, by the Massachusetts Medical Society

Volume 329

DECEMBER 9, 1993

Number 24

### AN ASSOCIATION BETWEEN AIR POLLUTION AND MORTALITY IN SIX U.S. CITIES

DOUGLAS W. DOCKERY, SC.D., C. ARDEN POPE III, PH.D., XIPING XU, M.D., PH.D.,  
JOHN D. SPENGLER, PH.D., JAMES H. WARE, PH.D., MARTHA E. FAY, M.P.H.,  
BENJAMIN G. FERRIS, JR., M.D., AND FRANK E. SPEIZER, M.D.

**Abstract Background.** Recent studies have reported associations between particulate air pollution and daily mortality rates. Population-based, cross-sectional studies of metropolitan areas in the United States have also found associations between particulate air pollution and annual mortality rates, but these studies have been criticized, in part because they did not directly control for cigarette smoking and other health risks.

**Methods.** In this prospective cohort study, we estimated the effects of air pollution on mortality, while controlling for individual risk factors. Survival analysis, including Cox proportional-hazards regression modeling, was conducted with data from a 14-to-16-year mortality follow-up of 8111 adults in six U.S. cities.

**Results.** Mortality rates were most strongly associated with cigarette smoking. After adjusting for smoking and

other risk factors, we observed statistically significant and robust associations between air pollution and mortality. The adjusted mortality-rate ratio for the most polluted of the cities as compared with the least polluted was 1.26 (95 percent confidence interval, 1.08 to 1.47). Air pollution was positively associated with death from lung cancer and cardiopulmonary disease but not with death from other causes considered together. Mortality was most strongly associated with air pollution with fine particulates, including sulfates.

**Conclusions.** Although the effects of other, unmeasured risk factors cannot be excluded with certainty, these results suggest that fine-particulate air pollution, or a more complex pollution mixture associated with fine particulate matter, contributes to excess mortality in certain U.S. cities. (N Engl J Med 1993;329:1753-9.)





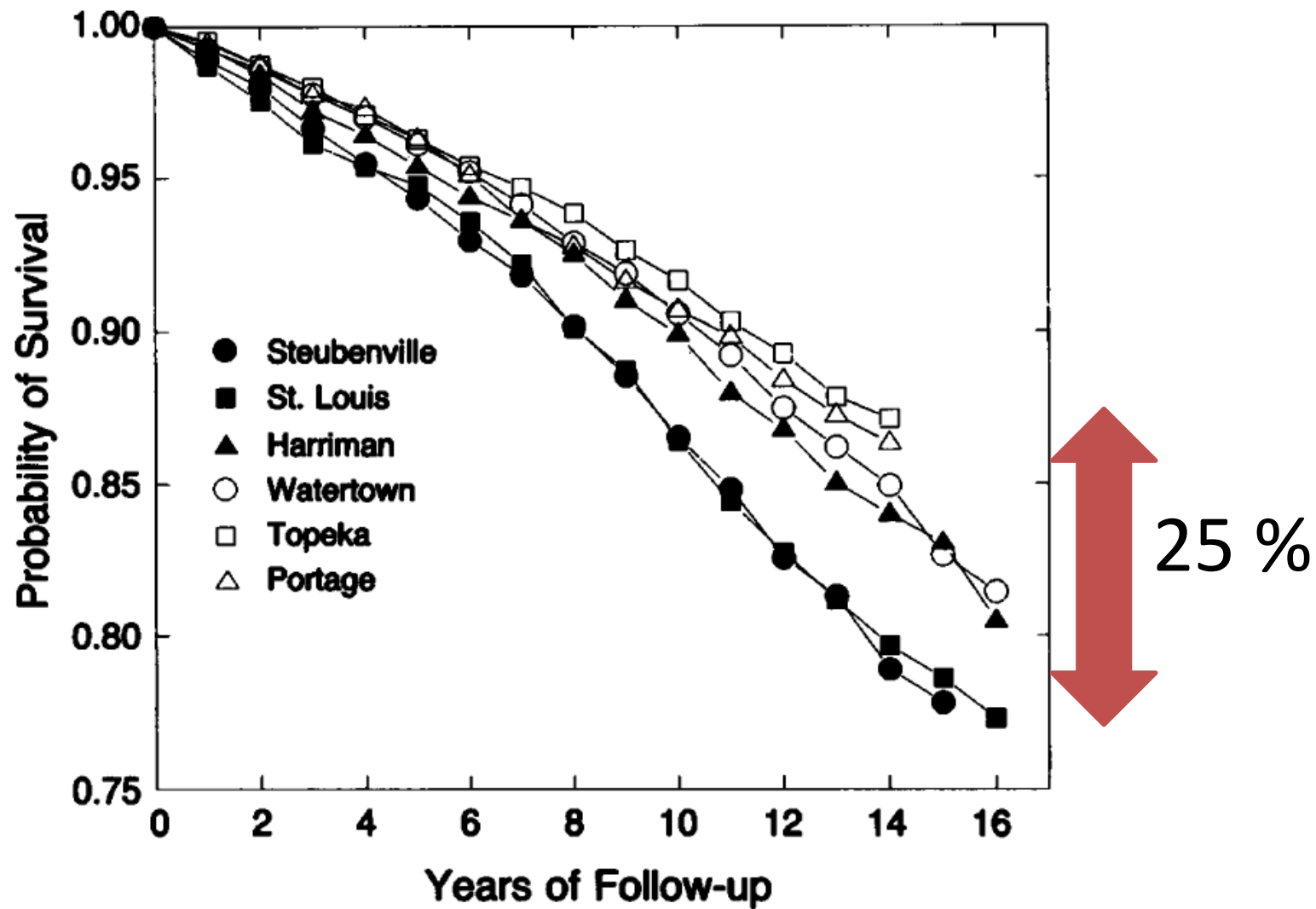


Figure 2. Crude Probability of Survival in the Six Cities, According to Years of Follow-up.



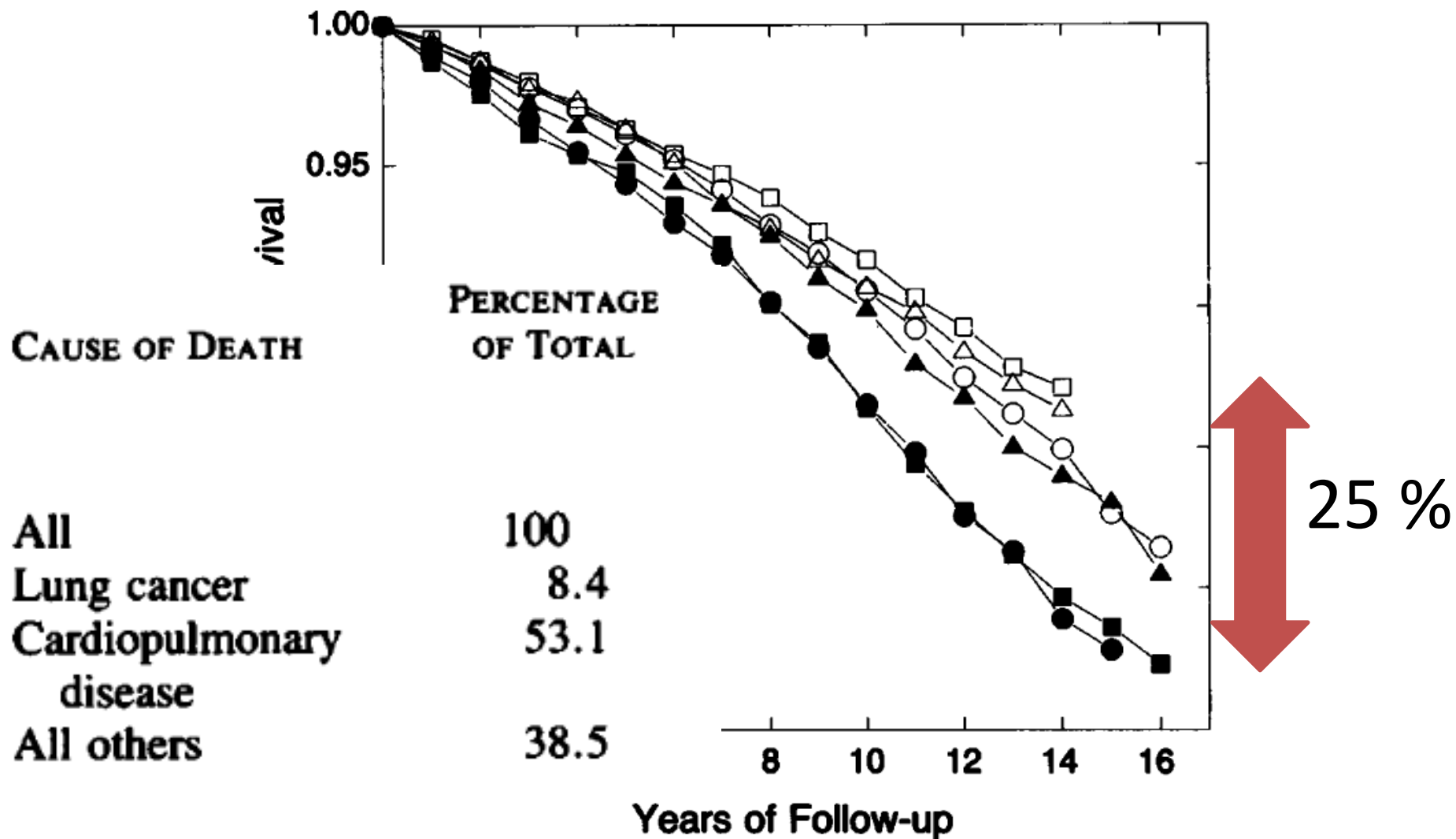


Figure 2. Crude Probability of Survival in the Six Cities, According to Years of Follow-up.



# 2004; 2010

## AHA Scientific Statement

### Particulate Matter Air Pollution and Cardiovascular Disease An Update to the Scientific Statement From the American Heart Association

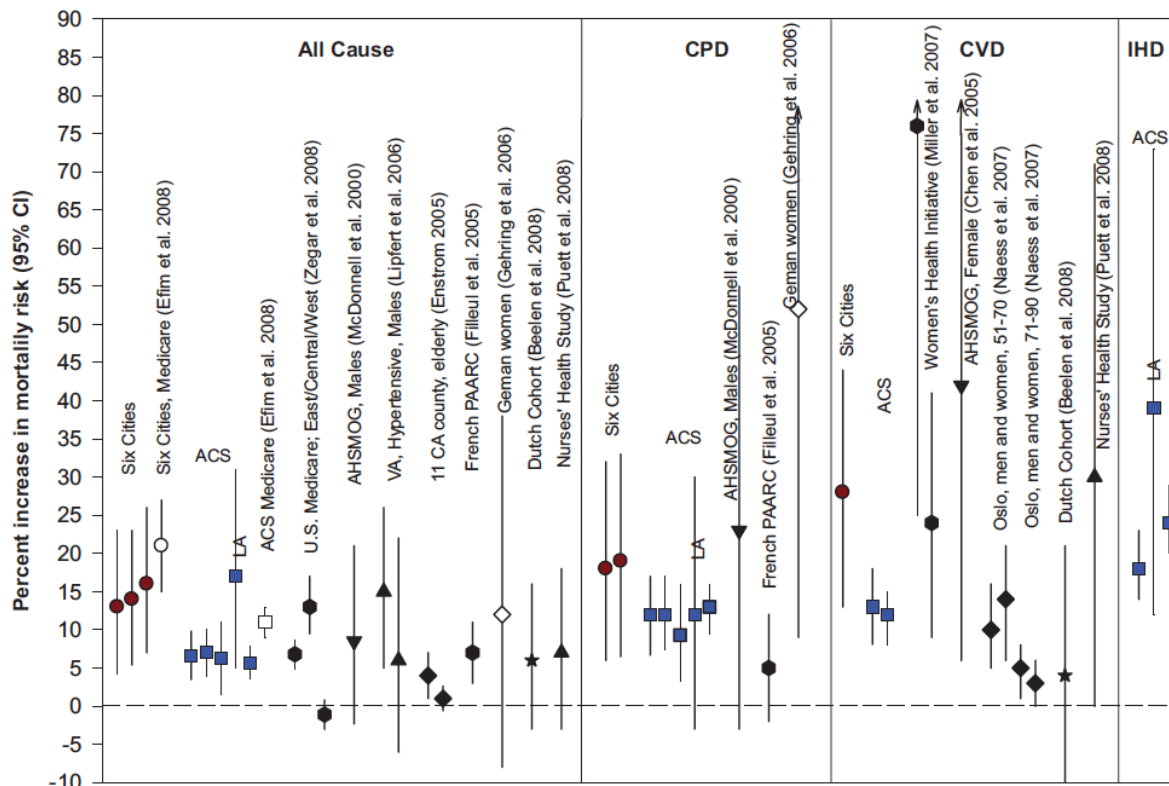
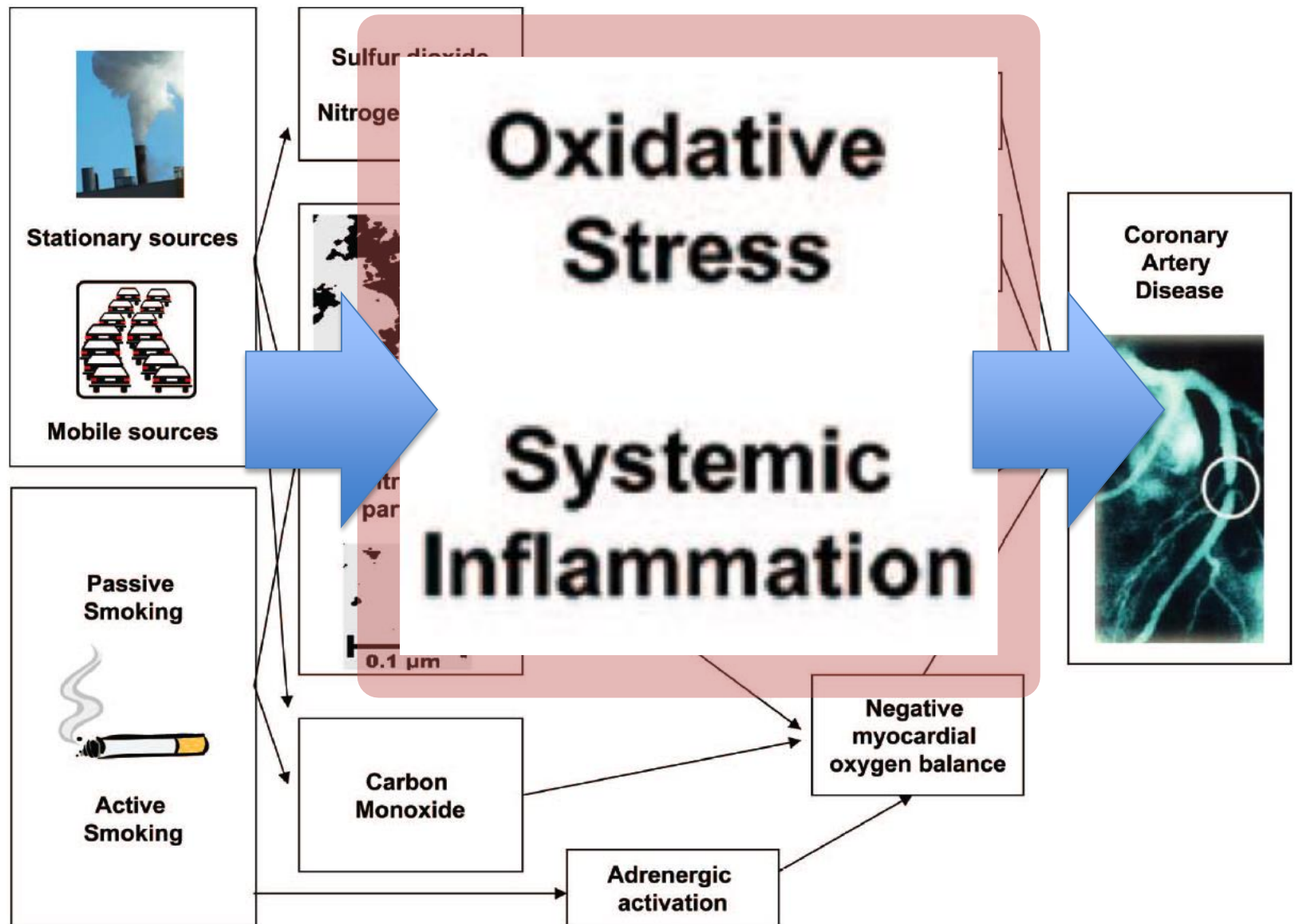


Figure 1. Risk estimates provided by several cohort studies per increment of  $10 \mu\text{g}/\text{m}^3$  in  $\text{PM}_{2.5}$  or  $\text{PM}_{10}$ . CPD indicates cardiopulmonary disease; IHD, ischemic heart disease.



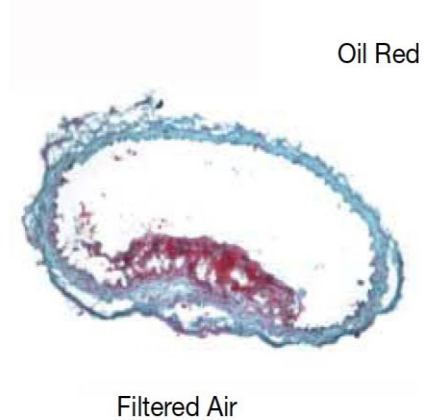




**Figure.** Overview on pathomechanism linking ambient air pollution,<sup>4</sup> secondhand smoke,<sup>7</sup> and active smoking to acute coronary syndromes.

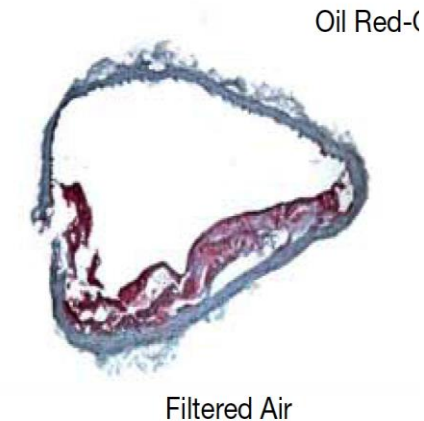
## Filtered air

Normal Chow



Exposure

High-Fat Chow



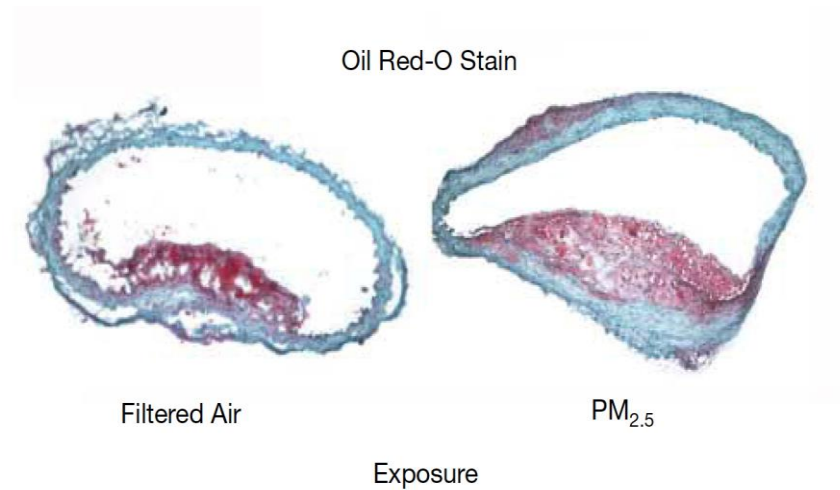
Exposure



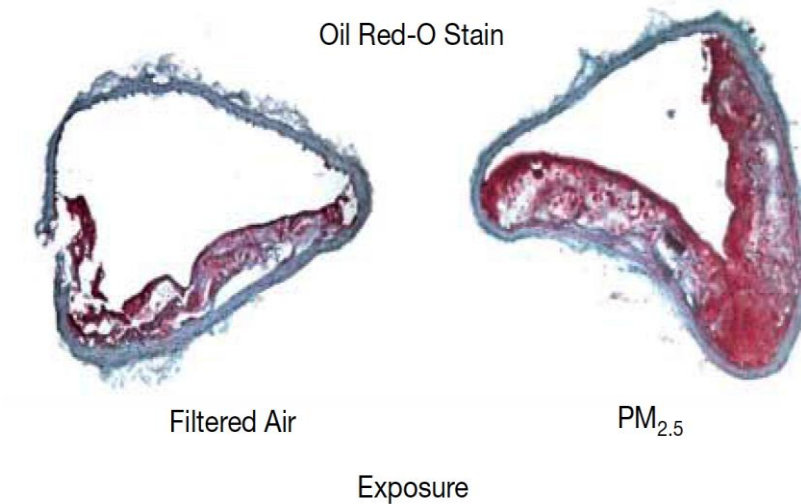
Filtered air

Polluted air

Normal Chow



High-Fat Chow



Long-term Air Pollution Exposure and Acceleration of Atherosclerosis and Vascular Inflammation in an Animal Model. JAMA 2005. 294: 3003-3010





World Health  
Organization, 2008

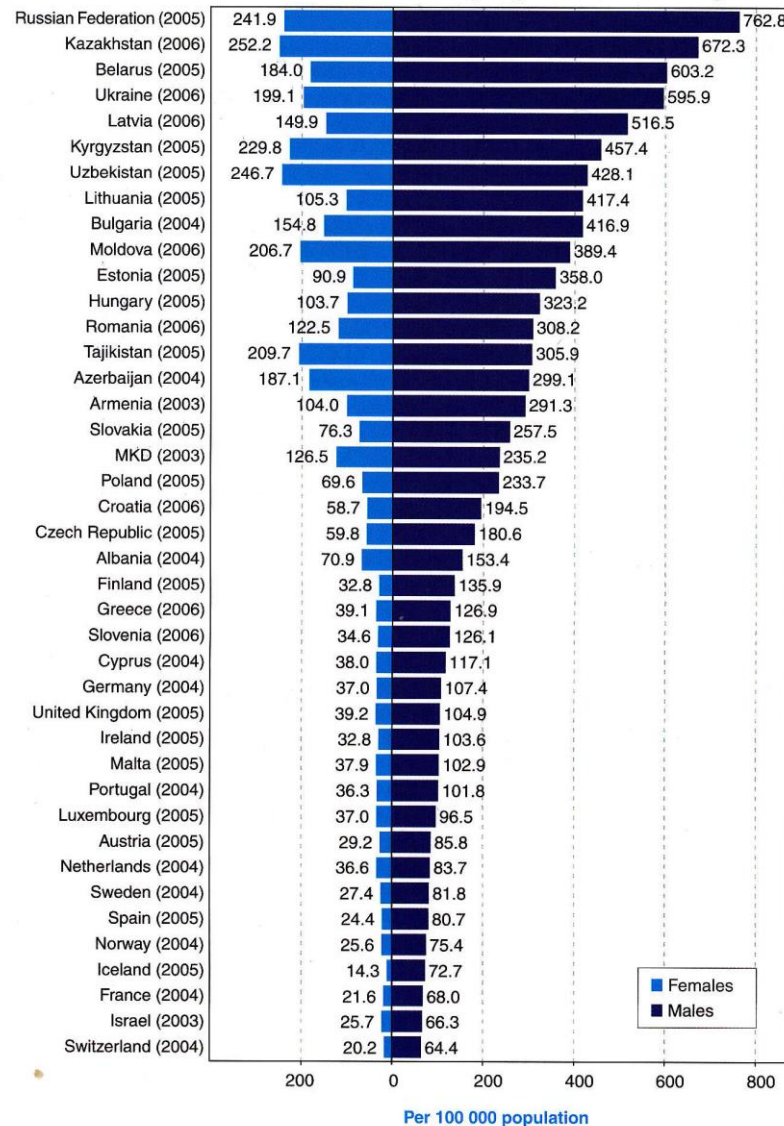
Russia

Poland

Austria

Switzerland

### Deaths from diseases of the circulatory system, 25–64 years



750

500

400

300

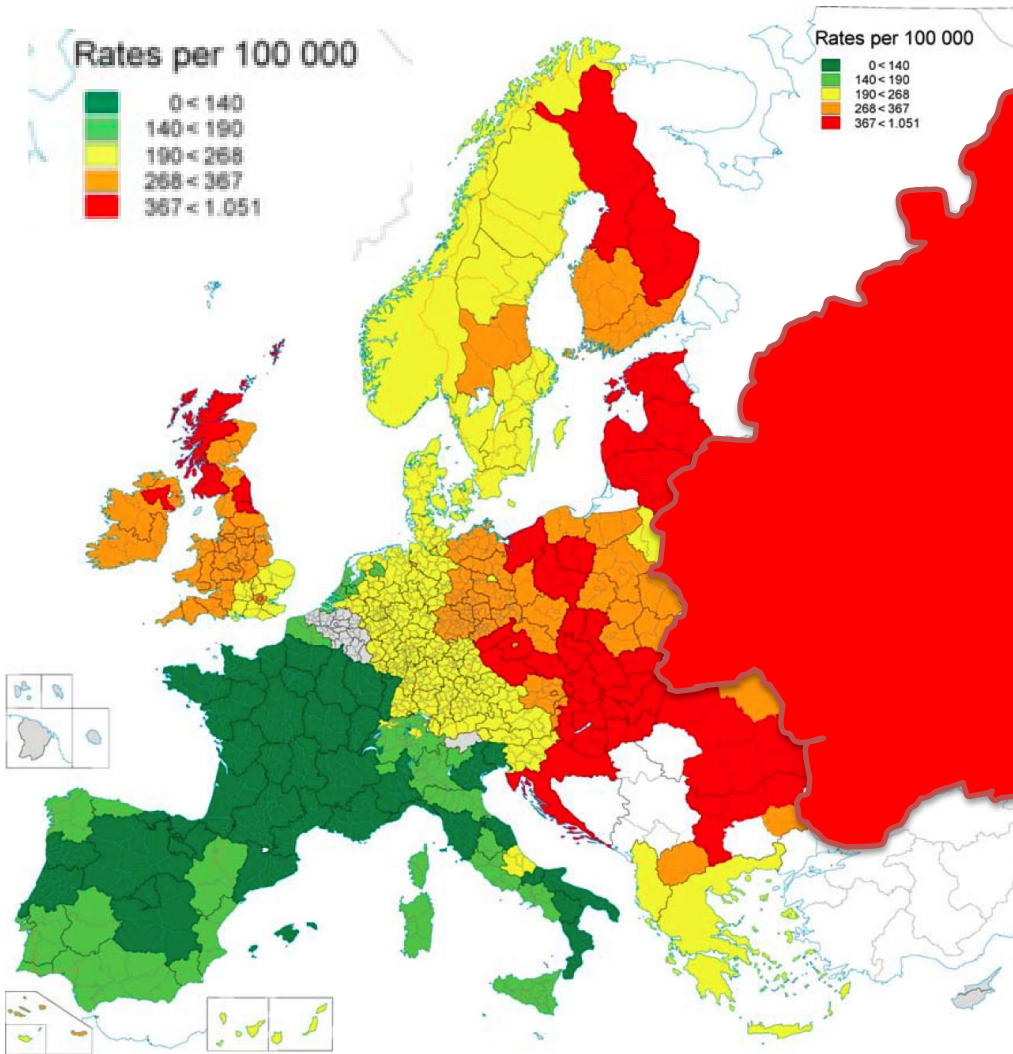
200

100

60

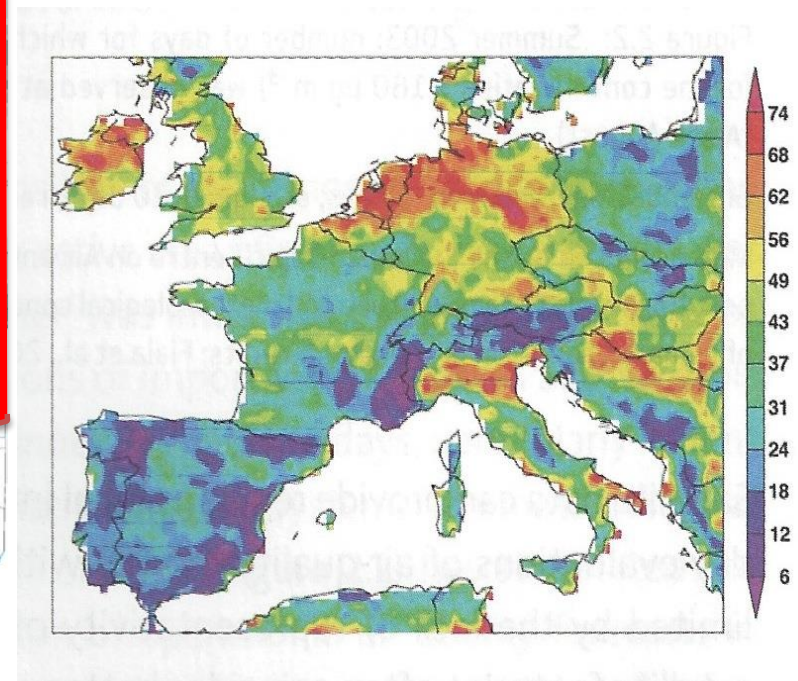


## Cardiovascular Mortality Men 45-74. Europe 2000



« An update on regional variation in cardiovascular mortality within Europe ». *European Heart Journal* 2008 doi : 10.1093/eurheartj/ehm604.

## Nb Events of Smog Europe 2003



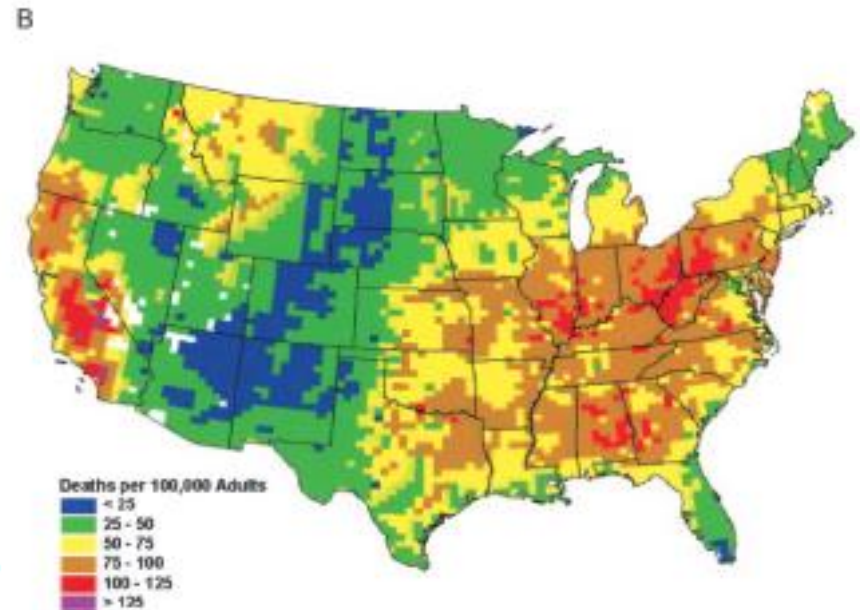
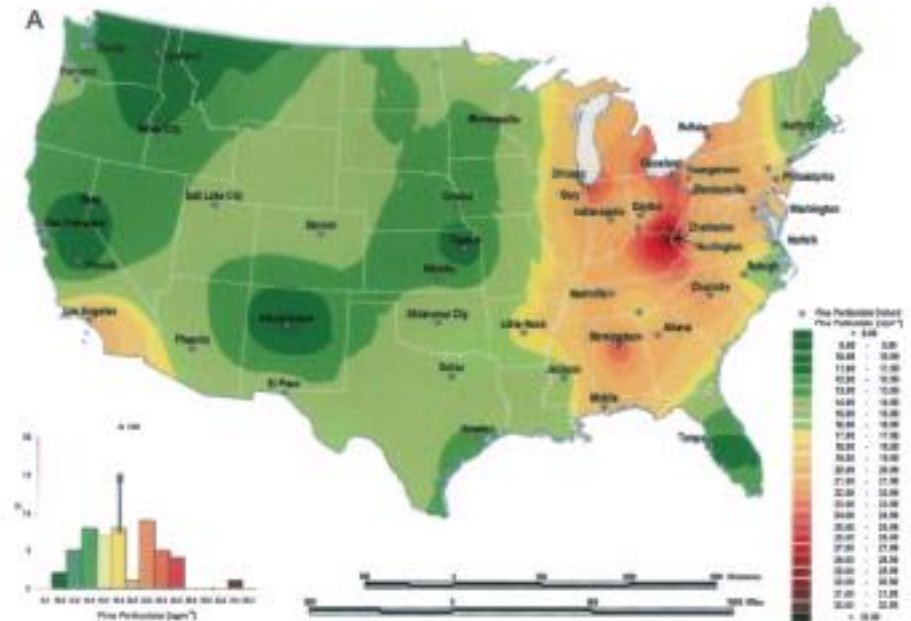
European Space Agency, Rapport TRAQ, Nov 2008



# Environmental Cardiology

## Studying Mechanistic Links Between Pollution And Heart Disease

Dr Aruni Bhatnagar  
St-Louis, Kentucky







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Organization

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## Media centre

# 7 million premature deaths annually linked to air pollution

News release

25 MARCH 2014 | GENEVA - In new estimates released today, WHO reports that in 2012 around 7 million people died - one in eight of total global deaths – as a result of air pollution exposure. This finding more than doubles previous estimates and confirms that air pollution is now the world's largest single environmental health risk. Reducing air pollution could save millions of lives.



# 2008

The environmental burden of disease in Canada: Respiratory disease, cardiovascular disease, cancer, and congenital affliction

David R. Boyd<sup>a,\*</sup>, Stephen J. Genuis<sup>b</sup>

- 20,000 deaths in excess
- 5-11 000 cardiovascular deaths
- 33-67 000 cardiac hospitalizations
- 1,5 million hosp days for heart disease
- 9,1 billion dollars

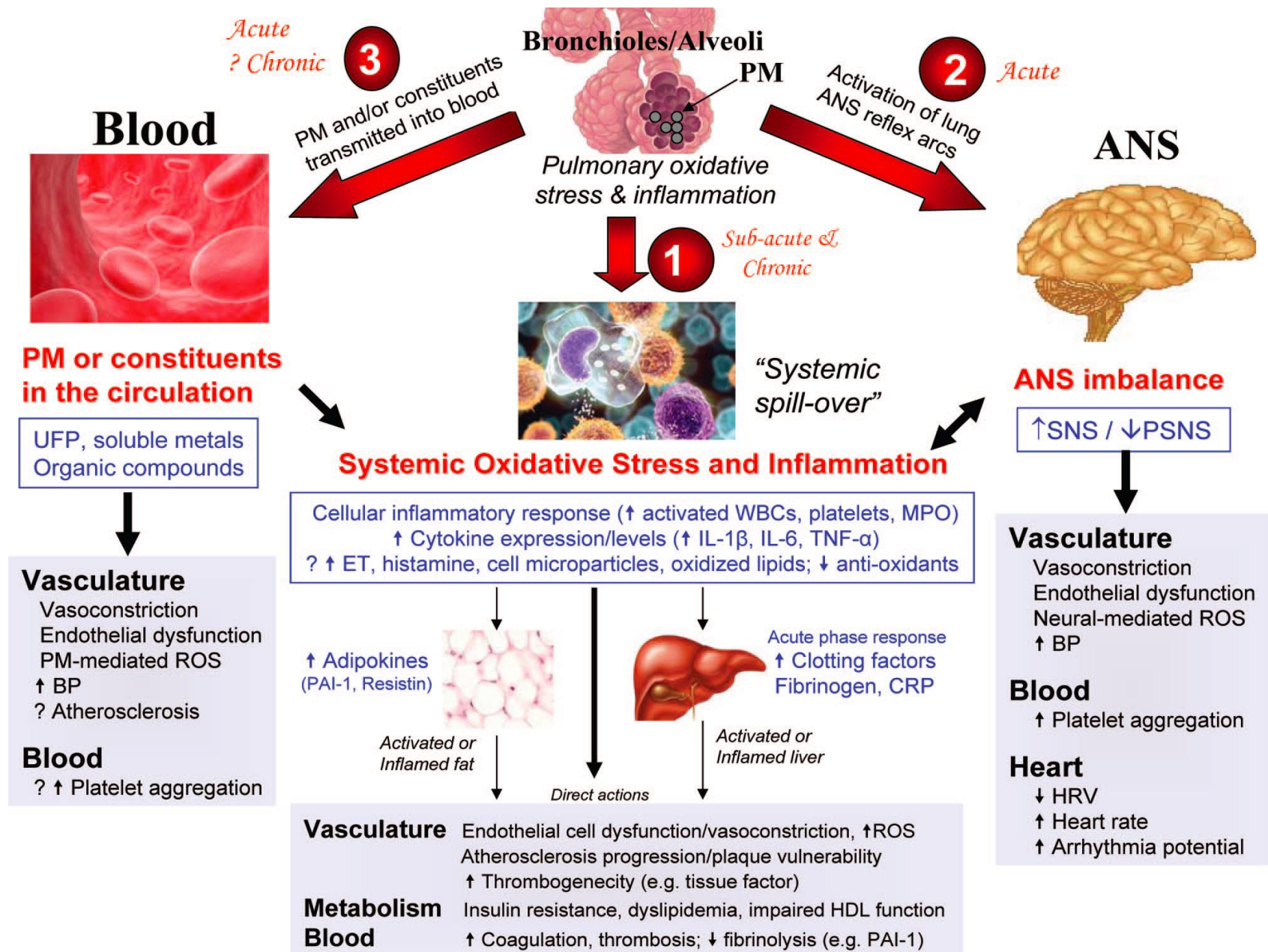


# ENVIRONMENT AND «CLASSIC» CARDIAC RISK FACTORS

If one presents with  
high blood pressure, diabetes, high  
cholesterol and obesity:

Does environment play a role?

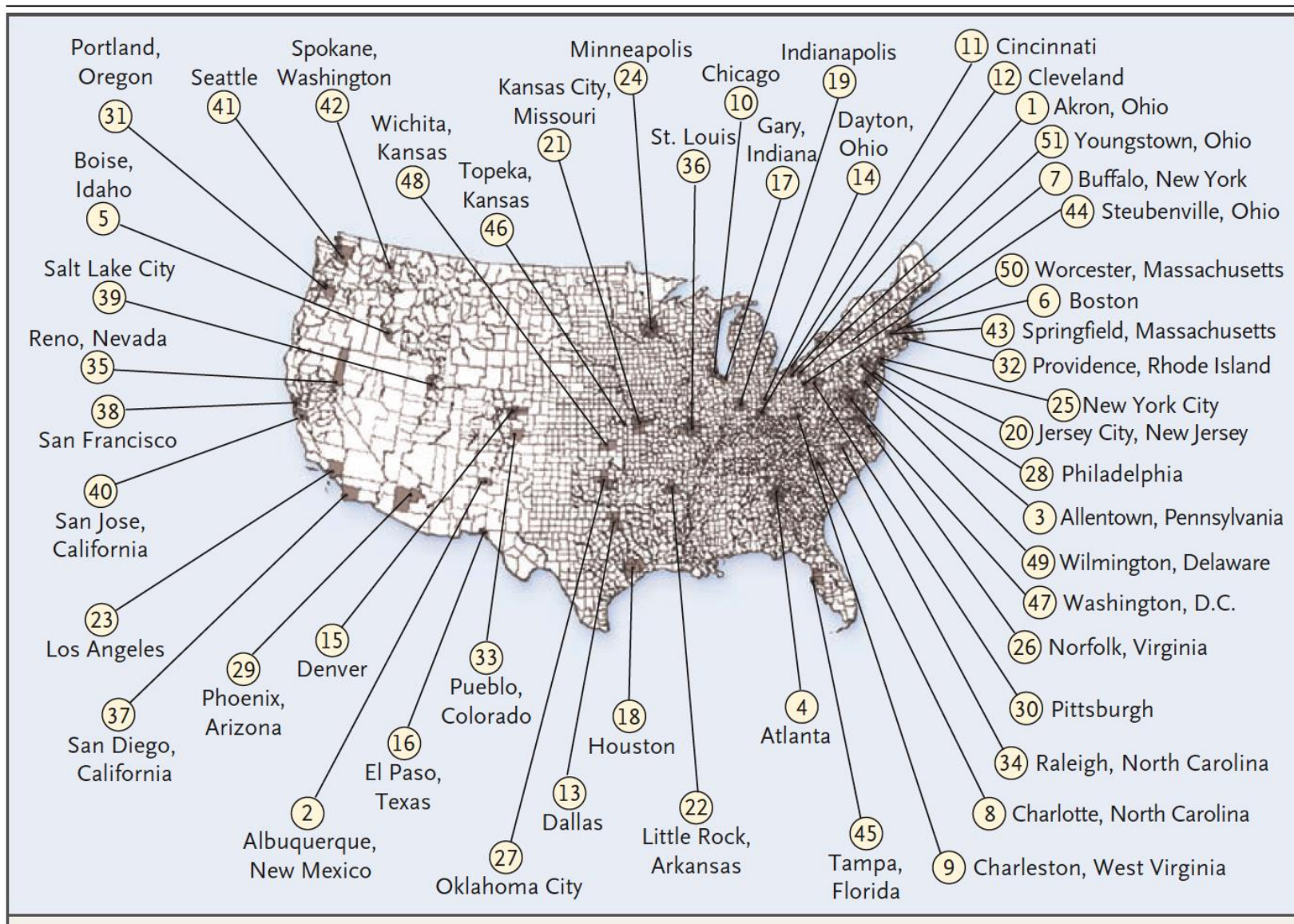






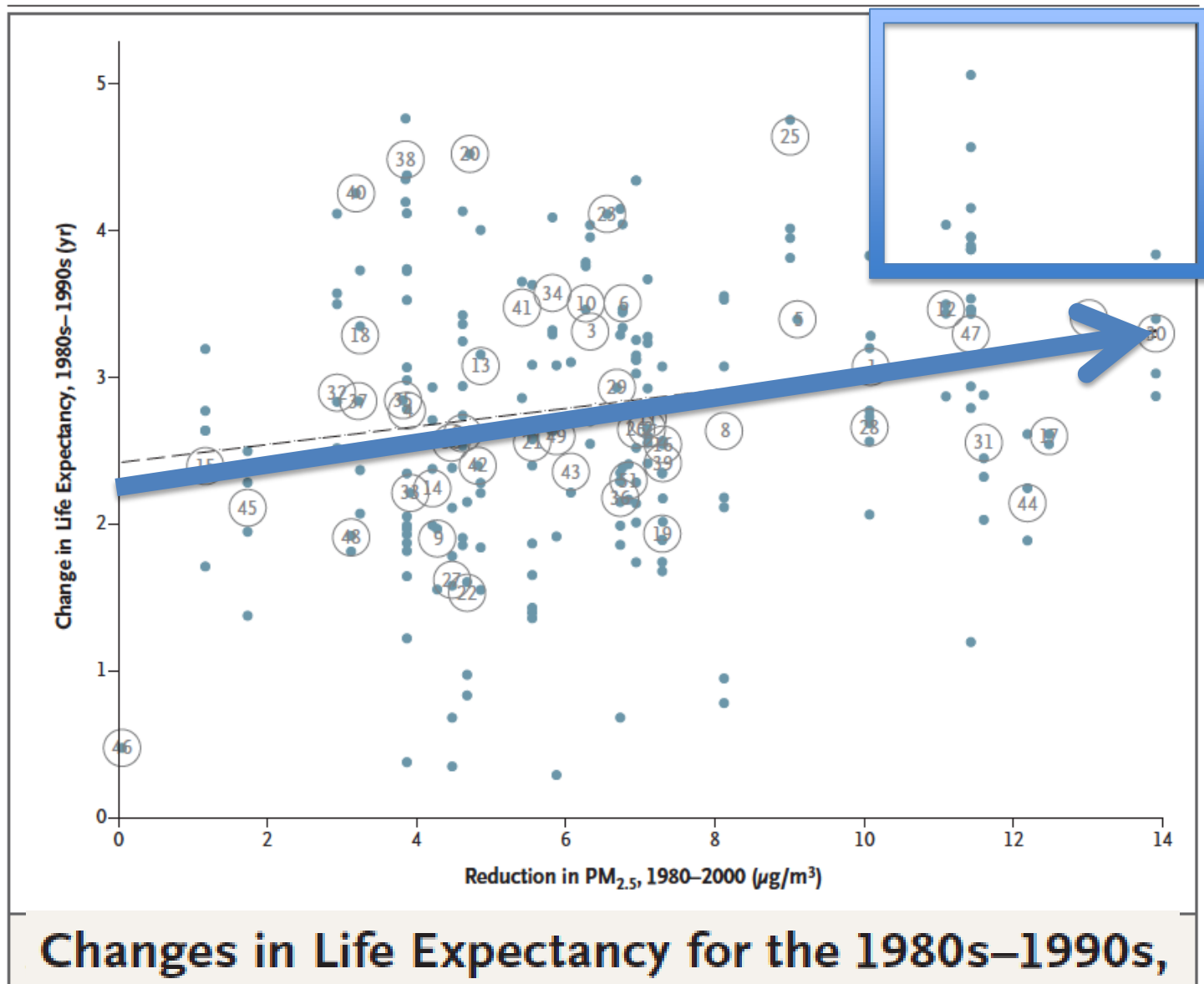
**DOES IT HELP  
IF WE CLEAN AIR ?**





Fine-particulate air pollution and life expectancy in the United States .  
 C. Arden Pope III, Majid Ezzati et Douglas W. Dockery.  
*New England Journal of Medicine* 2009 360 : 376-86.





Fine-particulate air pollution and life expectancy in the United States .  
 C. Arden Pope III, Majid Ezzati et Douglas W. Dockery.  
*New England Journal of Medicine* 2009 360 : 376-86.



Global warming  
Urban Heat Islands  
Pollution

Protect and  
plant trees !





**TABLE 1** Overview of positive effects from trees and other plant forms on the urban climate.



<b>AIR QUALITY</b>	Filtering out of dust and air pollution
<b>MICROCLIMATE</b>	Regulation of temperature extremes (through shade and shelter) Air humidification, making it cooler and more pleasant
<b>WATER MANAGEMENT</b>	Water storage and reduction of peaks in drainage needs at times of precipitation
<b>ENERGY SAVINGS</b>	Reduction in heat loss (from indoors) and need for cooling
<b>PROPERTY VALUES</b>	Higher in the vicinity of plants
<b>HEALTH</b>	Possibilities for relaxation and activity
<b>BIODIVERSITY</b>	Habitat for many organisms
<b>LIMITATION OF GREENHOUSE EFFECT</b>	Sequestering of CO <sub>2</sub>
<b>LANDSCAPE</b>	Screening of traffic and industry
<b>AESTHETICS</b>	Beautification of streets and neighbourhoods

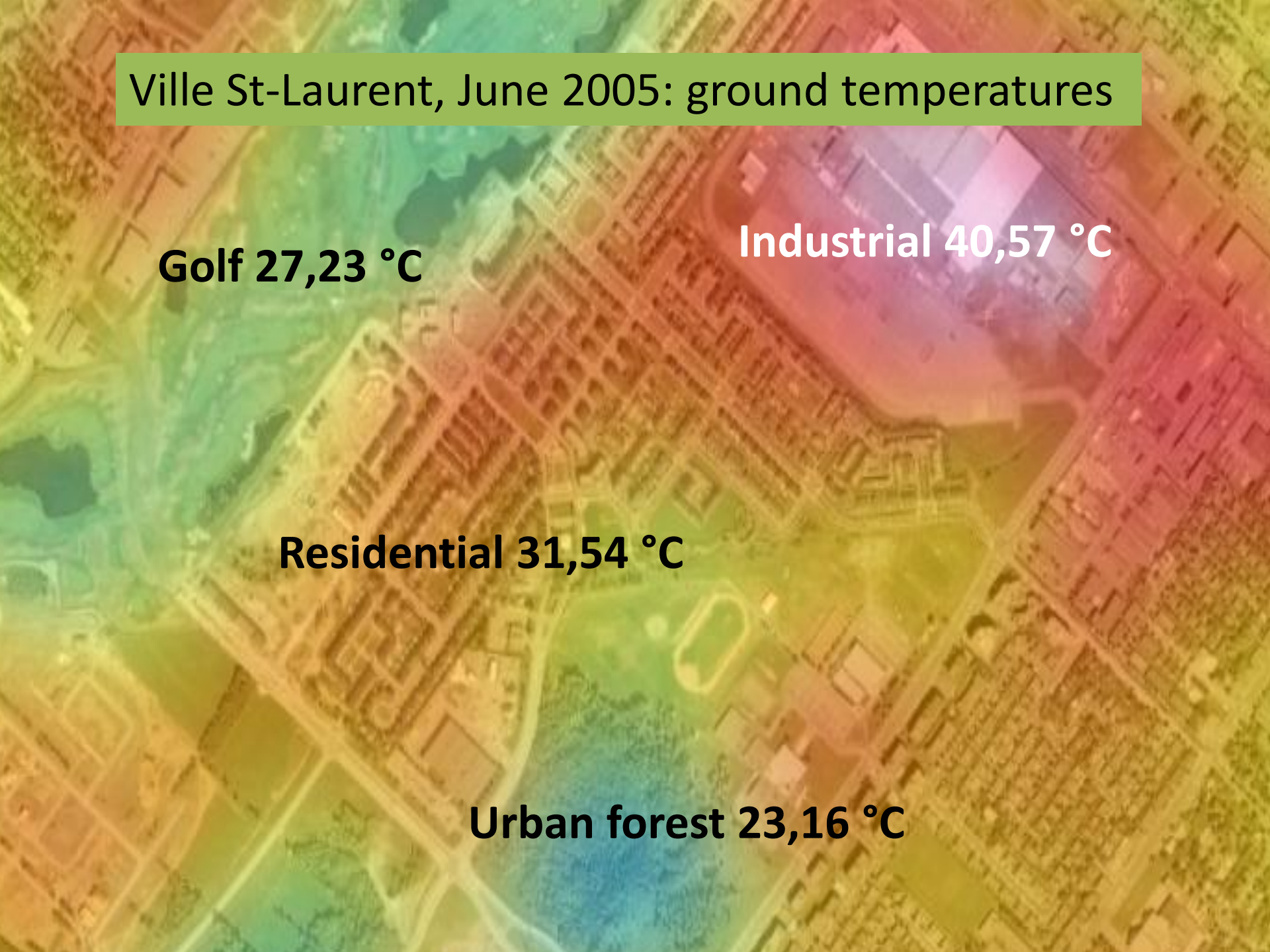




# Urban Heat Islands: Biotoques Study



# Ville St-Laurent, June 2005: ground temperatures

The image is a thermal map of Ville St-Laurent, Quebec, Canada, from June 2005. It shows ground temperatures across different urban areas. The map uses a color scale where cooler temperatures are represented by blue and green, and warmer temperatures are represented by yellow, orange, and red. The background is an aerial photograph of the city, with the thermal overlay showing temperature variations. The industrial area in the top right is the warmest, shown in bright red. The residential area in the center is shown in orange and yellow. The golf course on the left is shown in green. The urban forest area at the bottom is the coolest, shown in blue and green.

**Golf 27,23 °C**

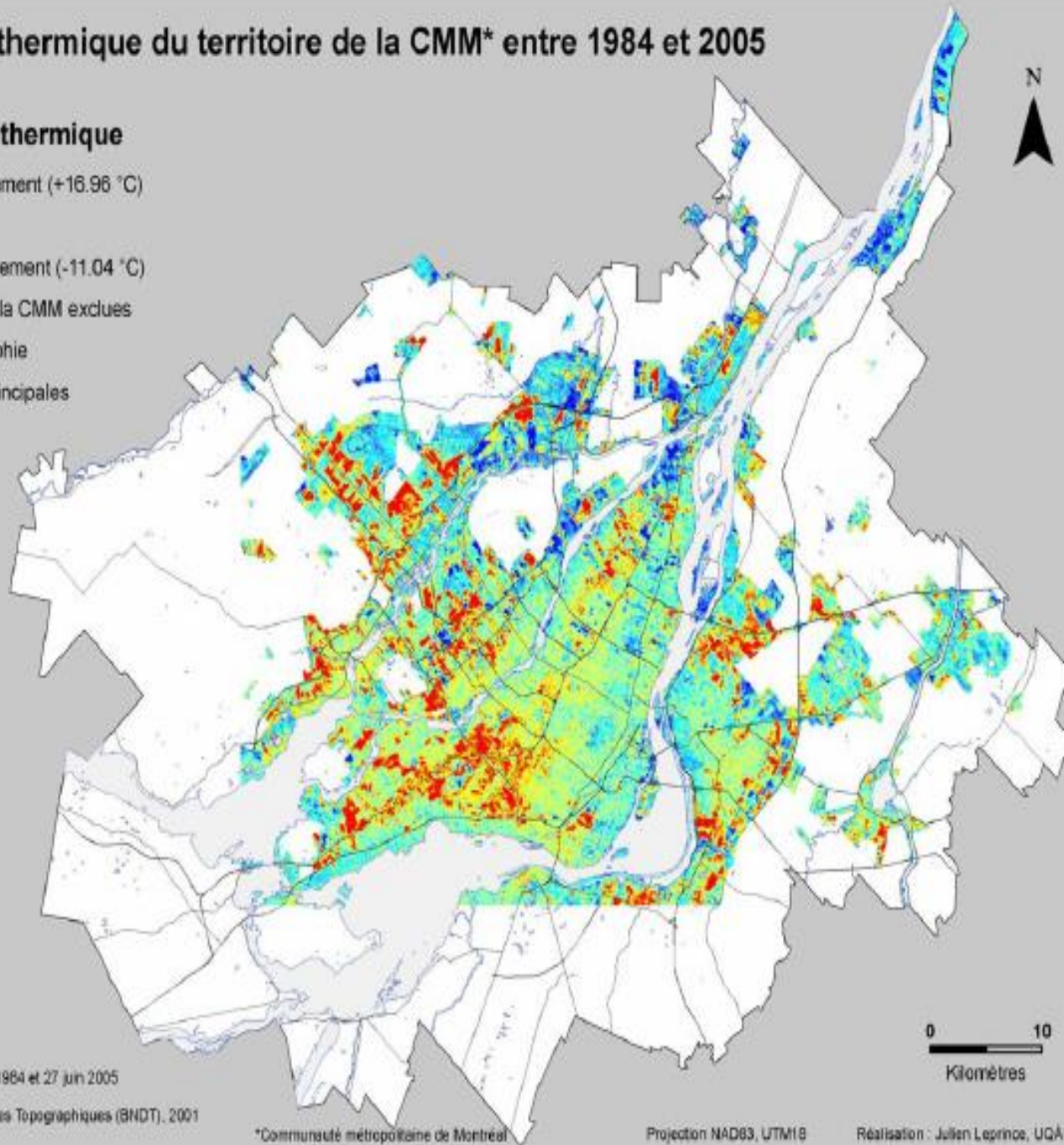
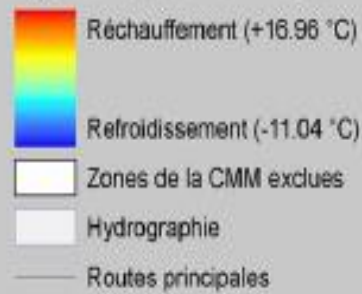
**Industrial 40,57 °C**

**Residential 31,54 °C**

**Urban forest 23,16 °C**

# Évolution thermique du territoire de la CMM\* entre 1984 et 2005

## Dynamique thermique



Sources :  
- Image Landsat 5, 17 juin 1984 et 27 juin 2005  
- CMM\*  
- Base Nationale de Données Topographiques (BNDT), 2001  
- GeoBase, 2006

\*Communauté métropolitaine de Montréal

Projection NAD83, UTM18

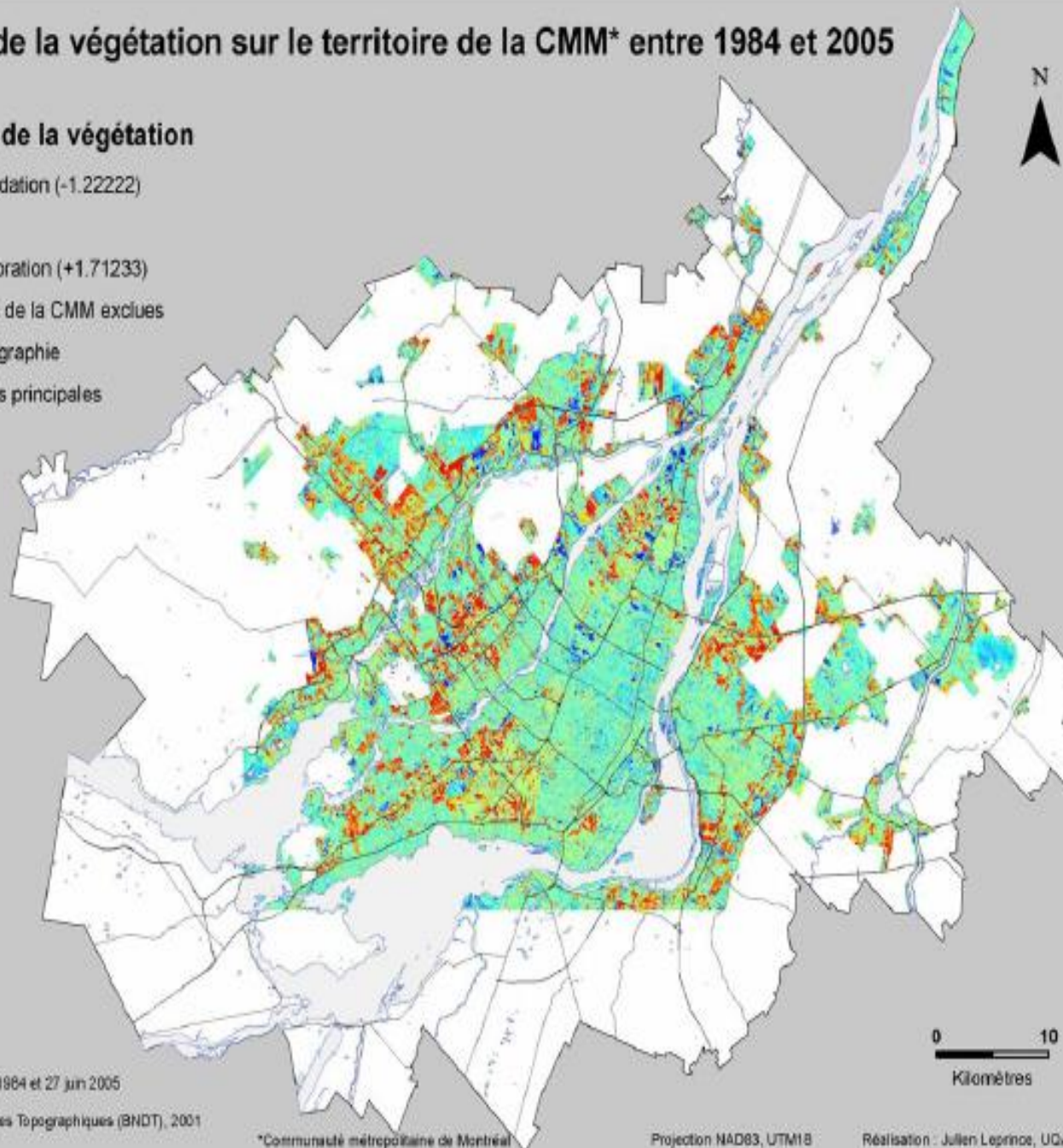
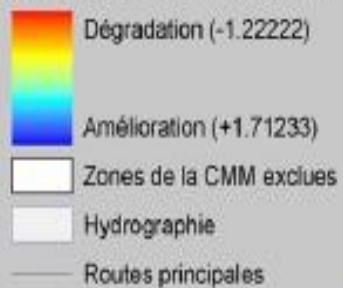
Réalisation : Julien Leprince, UQAM 2007





# Évolution de la végétation sur le territoire de la CMM\* entre 1984 et 2005

## Dynamique de la végétation



### Sources :

- Image Landsat 5, 17 juin 1984 et 27 juin 2005
- CMM\*
- Base Nationale de Données Topographiques (BNDT), 2001
- GéoBase, 2006

\*Communauté métropolitaine de Montréal

Projection NAD83, UTM18

Réalisation : Julien Leprince, UQAM 2007



# The 2003 Heat Wave in Europe:

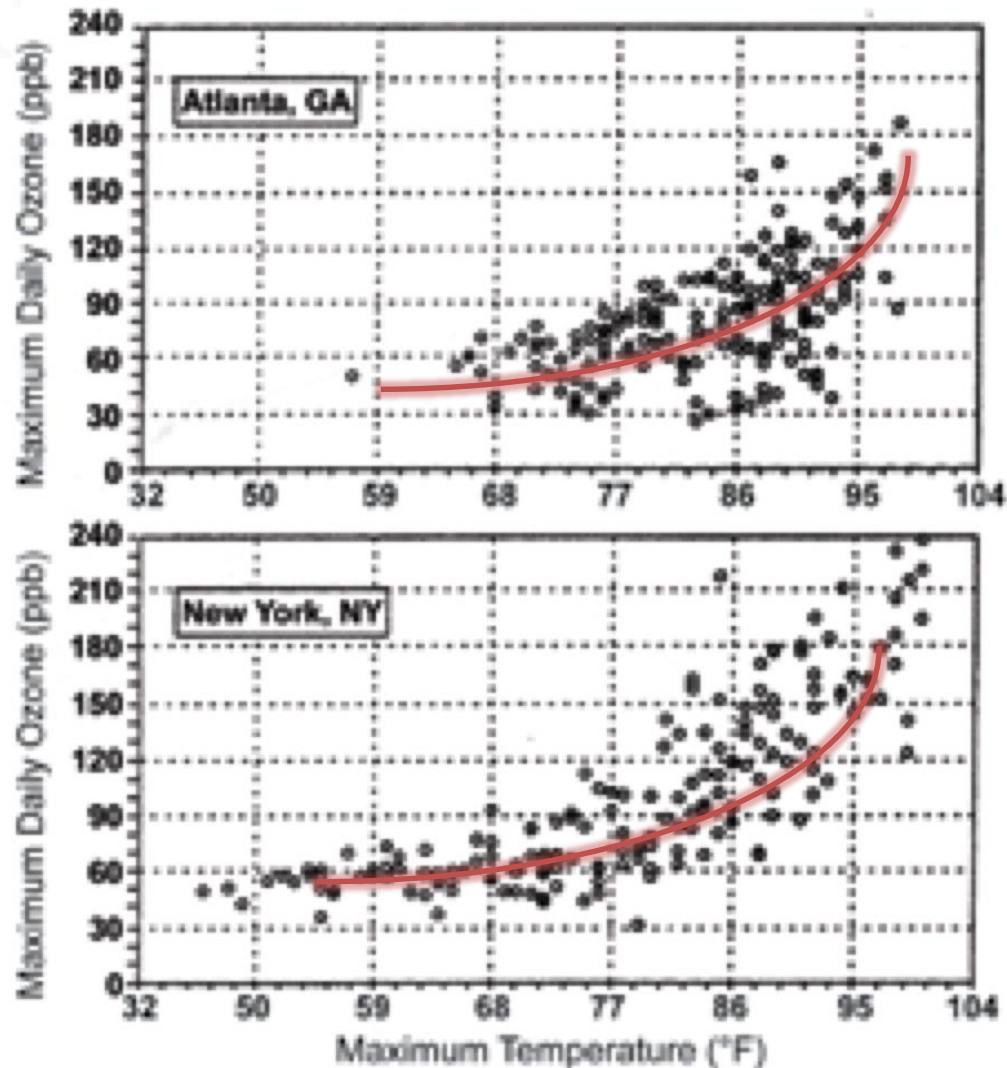
70,000 deaths in excess

18,000 deaths in France

- ✓ The first time the French life expectancy dropped since WWII
- ✓ Deaths concentrated in mineralized milieus compared to green milieus.



# Warming increases pollutants toxicity







## News



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Press Release 10-196

## Plants Play Larger Role Than Thought in Cleaning up Air Pollution

Chemicals known as oxygenated volatile organic compounds (oVOCs) affect environment, human health



Poplars, aspens, other trees provide extensive "ecosystem services."



Deciduous trees in hardwood forests remove harmful chemicals from the atmosphere.

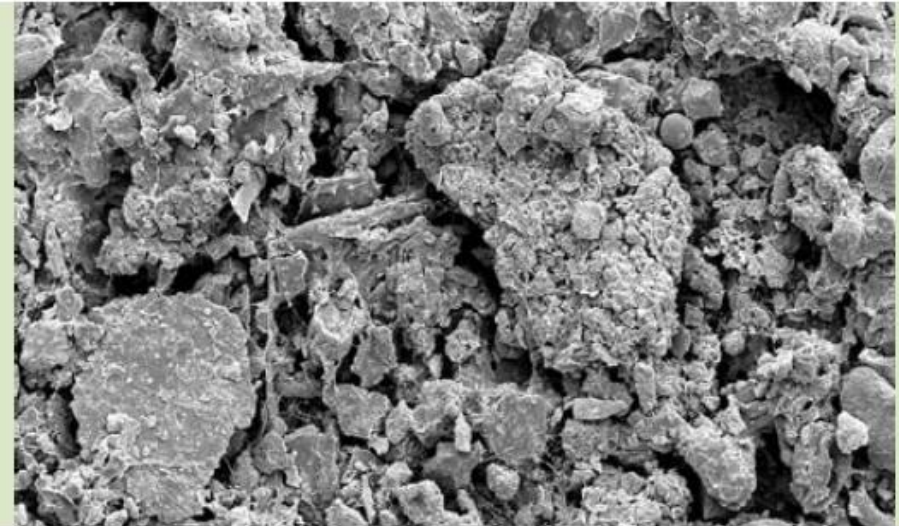
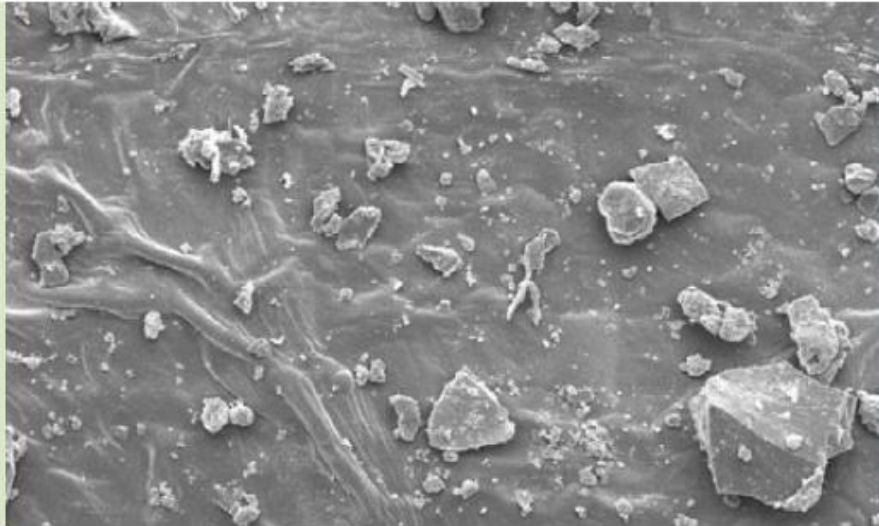
[Credit and Larger Version](#)



Trees absorb more of a common air-polluting chemical than thought.

[Credit and Larger Version](#)



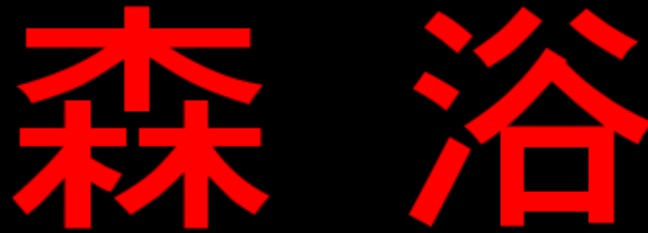


Particulates on the leaf of Parthenocissus (Virginia Creeper) in June (left) and in October (right)  
**Absorption of different types of air pollution by leaves.**

POLLUTION TYPE	MECHANISM	APPROPRIATE LEAF TYPES
Ozone, nitrogen dioxide	Absorption	Flat and broad leaves of deciduous trees
Volatile organic compounds, (PCB's, dioxins, furans)	Adsorption	Thick and sebaceous wax layer (cuticle) on the leaves,
Particulates (PM10)	Impaction	Pointed forms such as conifer needles. Coarse, hairy and sticky leaves of deciduous trees

SPECIES	PARTICULATES PM10	NITROGEN OXIDES NO+NO <sub>2</sub>	OZONE O <sub>3</sub>	EMISSIONS OF VOLATILE ORGANIC COMPOUNDS ③ ④
CONIFERS				
<i>Ginkgo biloba</i> *	■	■ ■ ■	■ ■ ■	■
<i>Metasequoia glyptostroboides</i>	■ ■ ■	■	■	■
<i>Pinus nigra</i>	■ ■ ■	■	■ +	■
<i>Pinus sylvestris</i> *	■ ■ ■	■	■	■
<i>Taxus</i>	■ ■ ■	■	■	■
HEDGES				
<i>Carpinus betulus</i>	■ ■	■ ■ ■	■ ■ ■	■
<i>Fagus</i>	■ ■	■ ■ ■	■ ■ ■	●
<i>Ligustrum</i>	■ ■	■ ■ ■	■ ■ ■	●
DECIDUOUS TREES				
<i>Acer platanoides</i> *	■	■ ■ ■	■ ■ ■ + ②	●
<i>Acer pseudoplatanus</i> *	■	■ ■ ■	■ ■ ■ +	●
<i>Aesculus</i>	■ ■	■ ■ ■	■ ■ ■	●
<i>Ailanthus altissima</i>	■	■ ■ ■	■ ■ ■	■
<i>Alnus cordata</i>	■	■ ■ ■	■ ■ ■ +	●
<i>Alnus glutinosa</i> *	■	■ ■ ■	■ ■ ■ +	●
<i>Alnus xspaethii</i>	■ ■	■ ■ ■	■ ■ ■ +	●
<i>Betula ermanii</i> *	■ ■	■ ■ ■	■ ■ ■ +	■
<i>Betula nigra</i>	■ ■	■ ■ ■	■ ■ ■ +	■
<i>Betula pendula</i>	■ ■	■ ■ ■	■ ■ ■ +	■



The image shows the Japanese characters for 'Shinrin-yoku' (Forest Bathing) in red. The character '森' (Shin) is on the left, composed of three '木' (tree) characters. The character '浴' (yoku) is on the right, composed of '入' (enter) and '浴' (bath). They are set against a black rectangular background.

# Shinrin-yoku

The term *Shinrin-yoku* (taking in the forest atmosphere or forest bathing) was coined by the Japanese Ministry of Agriculture, Forestry, and Fisheries in 1982. It can be defined as making contact with and taking in the atmosphere of the forest: a process intended to improve an individual's state of mental and physical relaxation [13]. *Shinrin-yoku* is considered to be the most widespread activity associated with forest and human health.



# 森 浴

Environ Health Prev Med (2010) 15:18–26

DOI 10.1007/s12199-009-0086-9

## SPECIAL FEATURE

The Trends on the Research of Forest Bathing in Japan,  
Korea and in the World

### The physiological effects of *Shinrin-yoku* (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan

Bum Jin Park · Yuko Tsunetsugu · Tamami Kasetani ·  
Takahide Kagawa · Yoshifumi Miyazaki

Received: 18 July 2008 / Accepted: 6 April 2009 / Published online: 2 May 2009

© The Japanese Society for Hygiene 2009





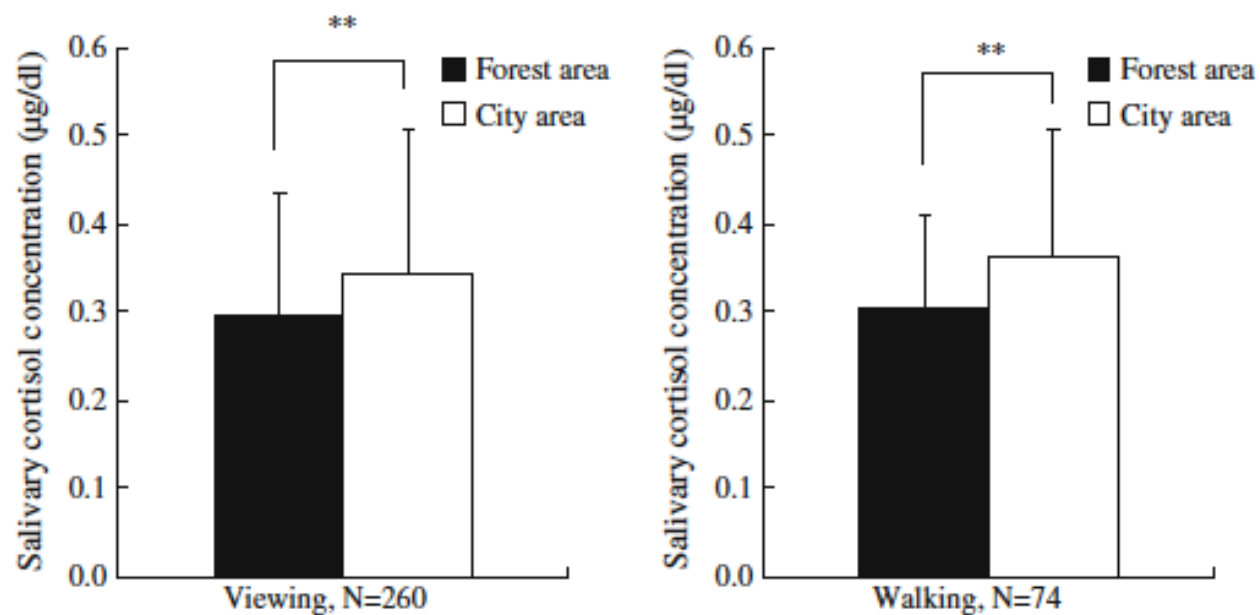


**Table 1** Measured physiological parameters and subjective evaluation

Autonomic nervous activity	Pulse rate, systolic blood pressure, diastolic blood pressure
	Heart rate variability (HRV)
	HF component (parasympathetic nervous activity)
	LF/HF or LF/(LF + HF) (sympathetic nervous activity)
Endocrine system activity	Salivary cortisol concentration
Immune system activity	Salivary immunoglobulin A concentration



**Fig. 2** Change in salivary cortisol concentration after forest viewing and walking. Mean  $\pm$  standard deviation (SD); \*\*  $p < 0.01$ ;  $p$ -value by  $t$  test



Cortisol level

Forest

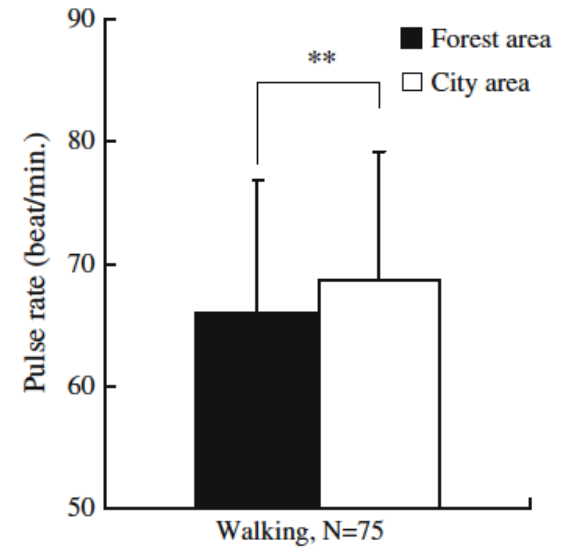
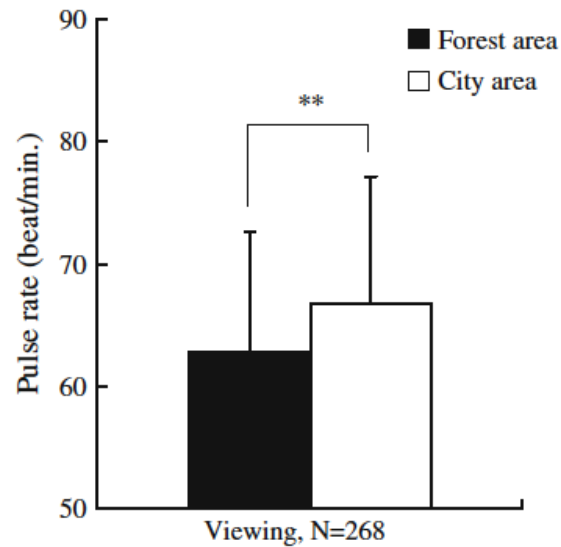


City



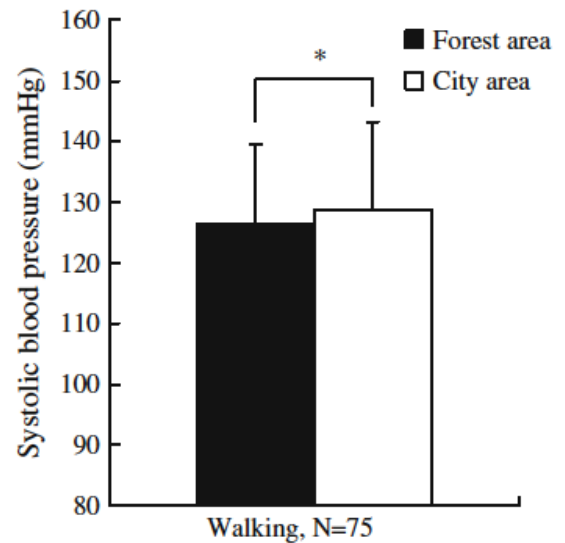
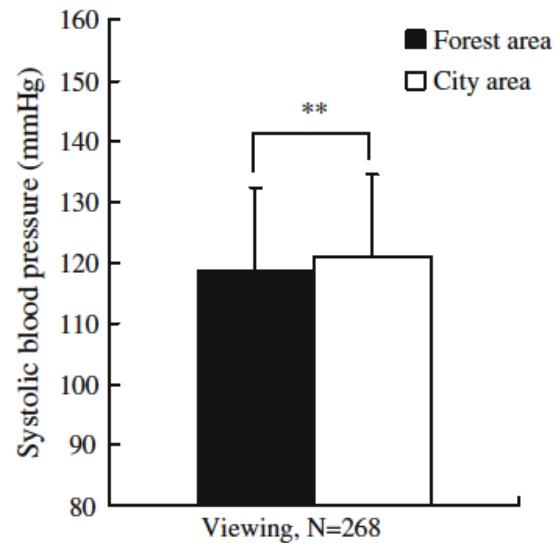
**Fig. 3** Change in pulse rate after forest viewing and walking. Mean  $\pm$  SD; \*\*  $p < 0.01$ ;  $p$  value by  $t$  test

Pulse rate  
in forest  
in city



**Fig. 4** Change in systolic blood pressure after forest viewing and walking. Mean  $\pm$  SD; \*\*  $p < 0.01$ ; \*  $p < 0.05$ ;  $p$  value by  $t$  test

Blood pressure  
in forest  
in city





methyl salicylate  
**alcaloïdes**

diterpenoïdes

**Limonoïdes**

saponine

**phenols**

cucurbitacine

cardenolide

**glucoside**

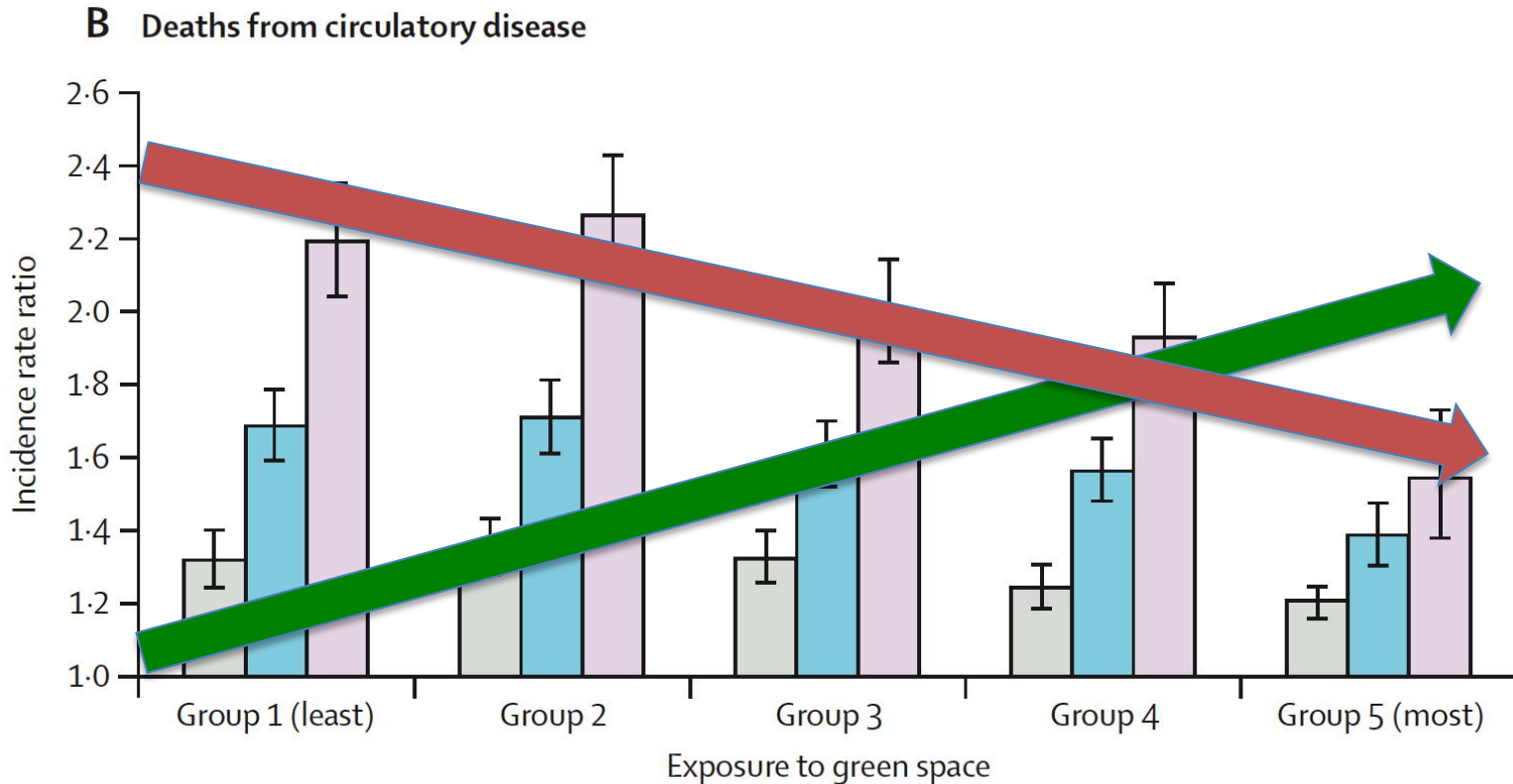




# Effect of exposure to natural environment on health inequalities: an observational population study

*Richard Mitchell, Frank Popham*

- ✓ 2001-2005
- ✓ 40 million of non-retired British subjects
- ✓ 360 000 deaths records
- ✓ 4 quartiles according to income
- ✓ 5 quintiles according to green exposure



**Green space exposure: 6% less mortality overall**

**Green space exposure: Reduction by half (from 219 % to 154 %) of the difference of cardiovascular death rate between poors (lower quartile) and riches (higher quartile).**



# The Relationship Between Trees and Human Health

## Evidence from the Spread of the Emerald Ash Borer

Geoffrey H. Donovan, PhD, David T. Butry, PhD, Yvonne L. Michael, ScD,  
Jeffrey P. Prestemon, PhD, Andrew M. Liebhold, PhD,  
Demetrios Gatzliolis, PhD, Megan Y. Mao



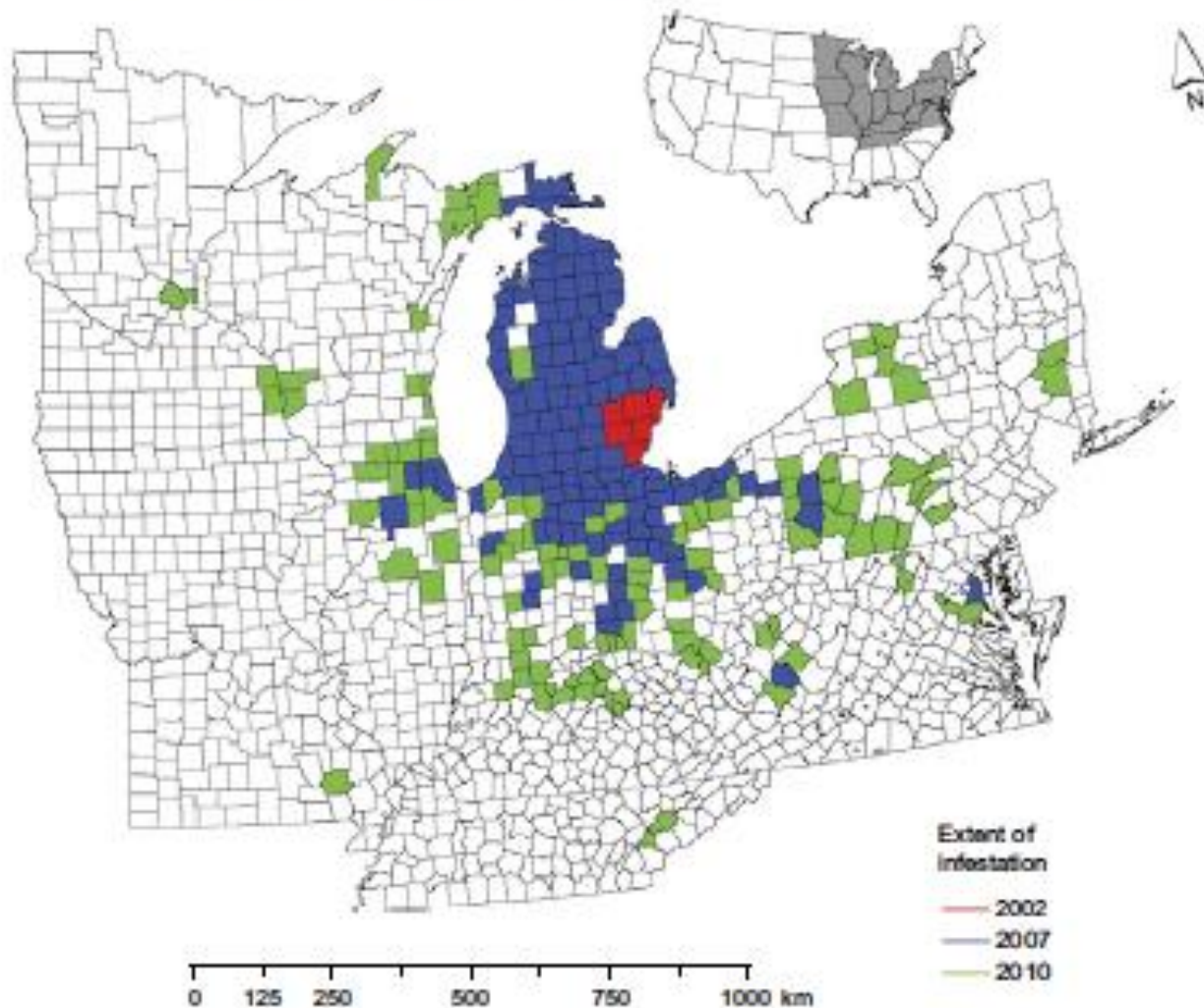


Figure 1. Counties where the emerald ash borer had been detected in 2002, 2007, and 2010







A tree-lined street in Toledo, Ohio in 2006,  
before emerald ash borer infestation.

Credit: Dan Herms, Ohio State University



Three years later, in 2009, after the invasive  
insect spread to the neighborhood.

Credit: Dan Herms, Ohio State University



In the 15 States where trees were destroyed

## **Increase of global mortality**

6,113 deaths in excess  
by pulmonary disease

15,080 deaths in excess  
by cardiovascular disease



# A cardio-protective city should

- Eradicate food nano-aggressors
- Eradicate airborne nano-aggressors
- Develop with renewable energies
  - Earth is geothermal
  - Wind is eolian
  - Water is hydrolic
  - Fire is solar
- Reconnect with nature/activity
- Aim at a 25 % urban canopy



# If a City eliminates

- Food nano-aggressors
  - Trans fat
  - Excess of salt
  - Added industrial sugars
  - Phosphoric acid
- Air nano-aggressors
  - CO
  - SO<sub>2</sub>, NO<sub>2</sub>
  - FP, UFP
  - VOC, HAP

and promotes a green and active milieu

**This City may expect a  
25-75 % reduction of cardiac disease**





"After all, CVD was not common in 1830, so why can't it now become uncommon by 2050? That is the challenge we all face."



Dr Salim Yusuf  
Cardiologist and Epidemiologist  
P.I. InterHeart Study  
McMaster University, Hamilton, Ontario



# Journée de l'Arbre de la santé

septembre 2007- septembre 2014







Centres hospitaliers























# Inauguration des sentiers de la santé et plantation de 250 arbres au CHUS

2012-09-24

Afin de souligner la Semaine nationale de l'arbre et des forêts, le Centre hospitalier universitaire de Sherbrooke a procédé à l'inauguration des sentiers de la Santé et à la plantation de 250 arbres autour de l'étang au CHUS – Hôpital Fleurimont.

« Ces deux projets démontrent bien l'approche innovatrice de la santé en Estrie et mettent en lumière certains rôles de notre hôpital, soit ceux d'être un milieu guérissant, qui favorise la promotion de la santé et l'engagement social. »

Patricia Gauthier, directrice générale du CHUS.





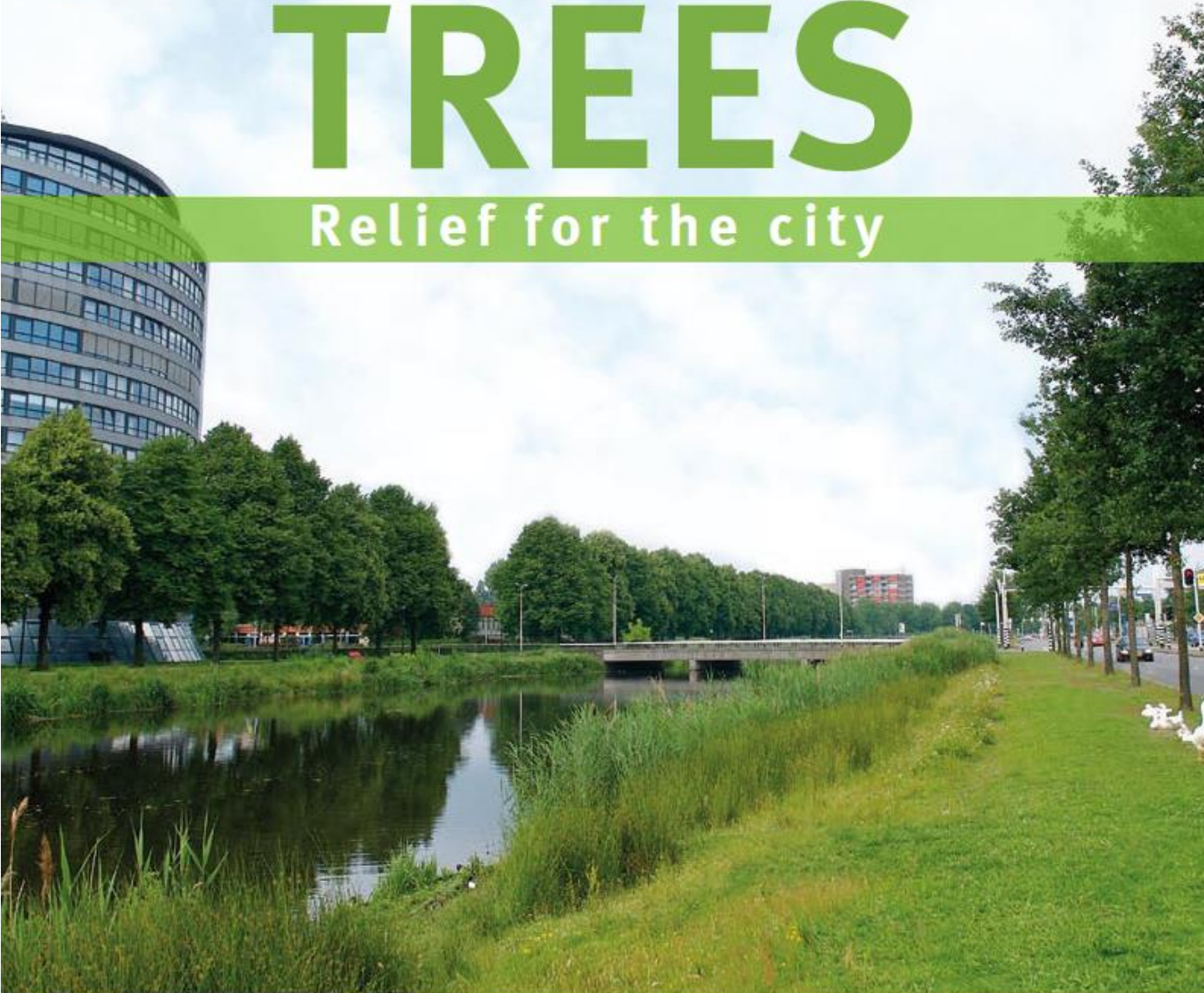




<http://edepot.wur.nl/20634>

# TREES

Relief for the city



Dr François Reeves

# PLANÈTE Cœur

Santé cardiaque et environnement



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CHU Sainte-Justine

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MULTIMONDES

Université   
de Montréal

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DAVID SUZUKI

FRANÇOIS REEVES, MD

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