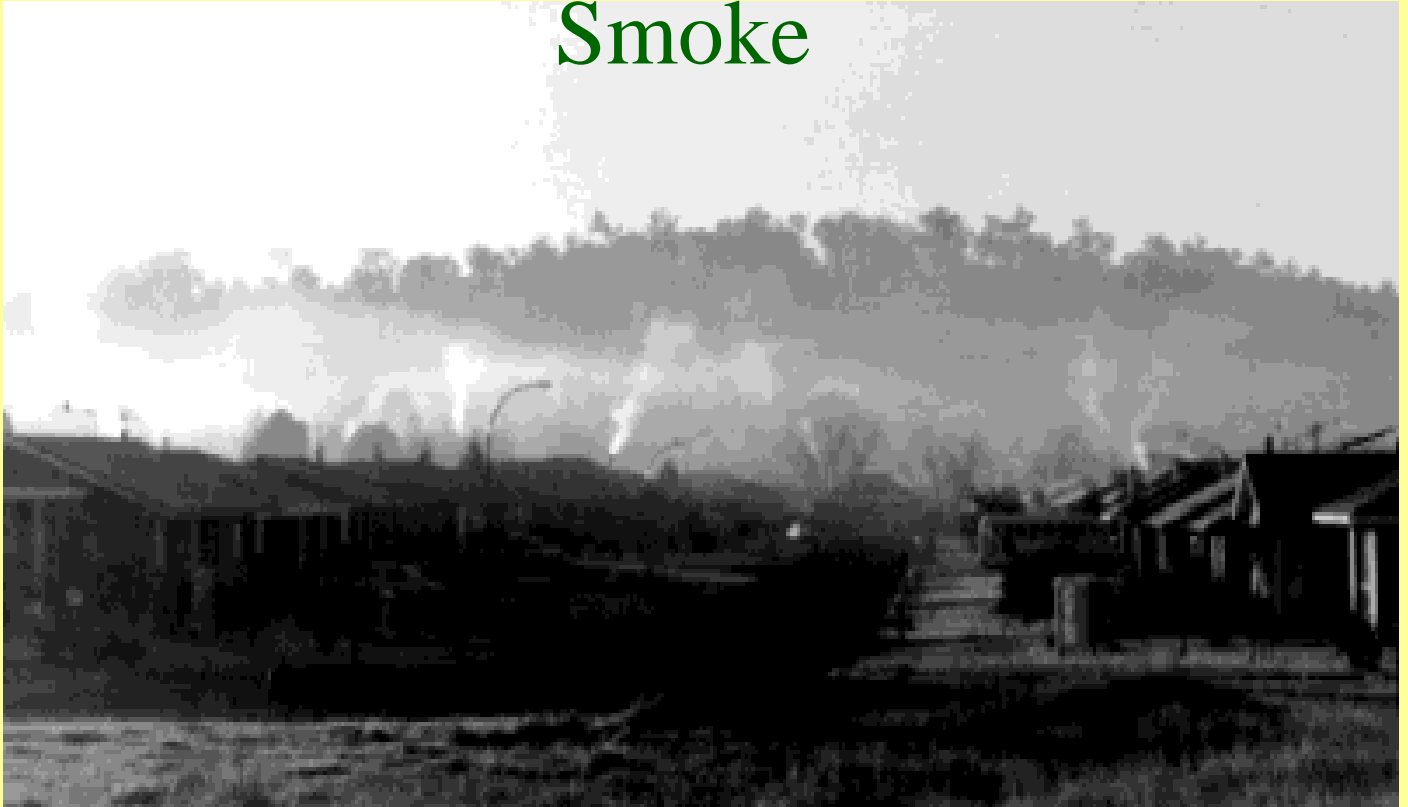


# The Economic Cost of Wood Smoke



Armidale Air Quality Group

*Many people do not take very seriously the loss of life and health due to air pollution, like that due to smoking, because they believe it is “only statistical”.*

Noel de Nevers

Air Pollution Control Engineering, 1995.



*Nowadays, health effects and economic costs of tobacco smoke taken very seriously....*

*What about air pollution?*

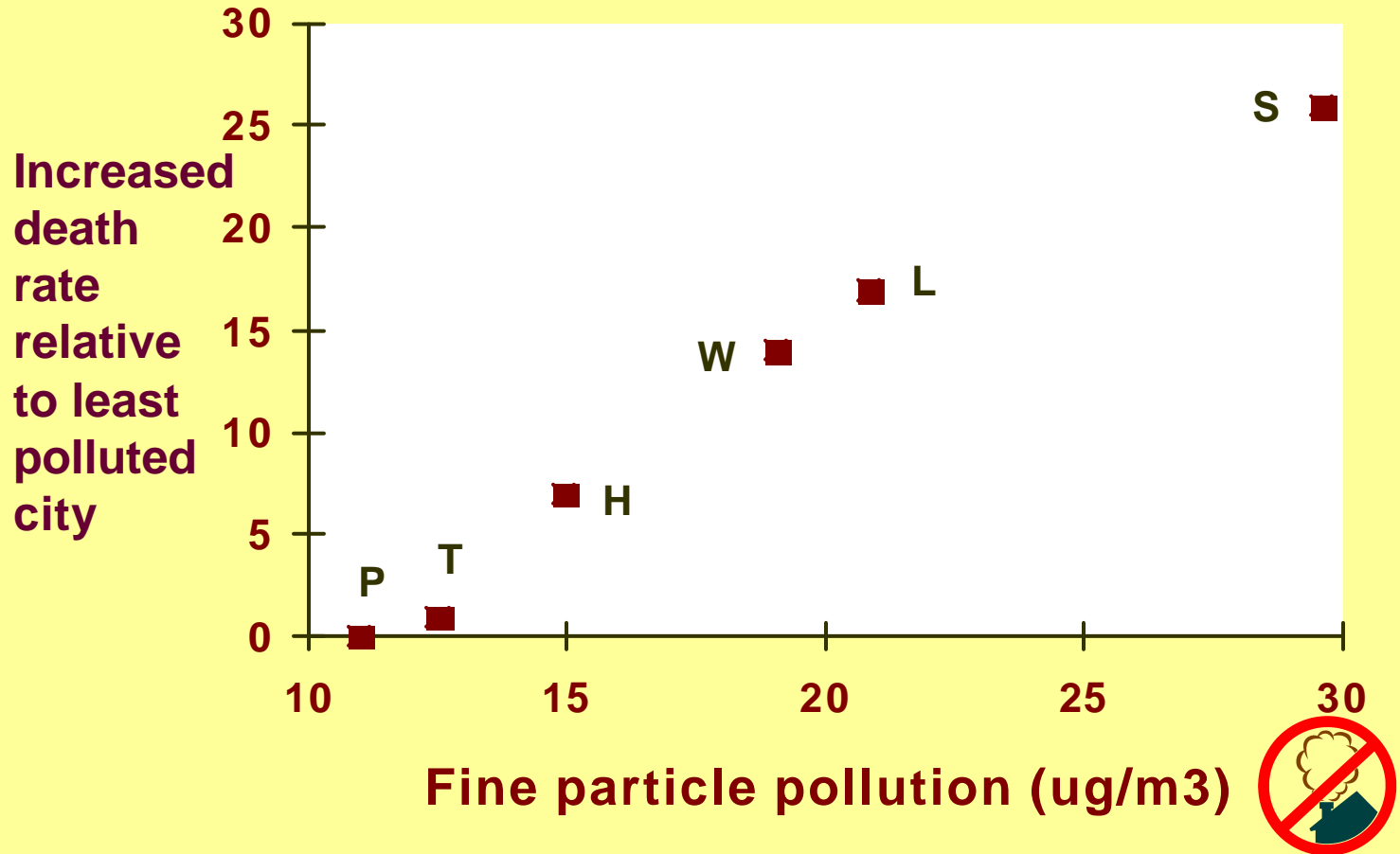


# Started to be taken seriously when studies revealed health problems

- ◆ E.g. Six US cities chosen to represent the range of particulate pollution in the US
- ◆ Study enrolled 8111 adults
- ◆ Comprehensive lifestyle questionnaire
- ◆ followed for 16 yrs - 1430 died
- ◆ Estimate death rates in each city adjusted for: cigarette smoking, education, body mass index



# Six Cities Study (US, 1993)



# Some cities took the problem seriously

- ◆ Follow-up study: PM<sub>2.5</sub> had dropped substantially in one city, moderately in another, remaining stable elsewhere.
- ◆ Death rates fell in the first two cities relative to the other four
- ◆ Strong evidence ... reducing pollution can save lives



# Dublin also reduced pollution

- ◆ Banned non-smokeless coal in September 1990
- ◆ 15.5% fewer respiratory and 10.3% fewer cardiovascular deaths in the 6 years after the ban, compared to the previous 6 years
- ◆ 116 fewer respiratory and 243 fewer cardiovascular deaths/year
- ◆ More than 2,000 lives saved in the first 6 years of the ban



# Two other long-term studies confirmed the 6 cities results

- ◆ The largest involved 500,000 subjects and 120,000 deaths
- ◆ A  $10\mu\text{g}/\text{m}^3$  increase in annual PM<sub>2.5</sub> increased cardiopulmonary mortality by 6-9% and lung cancer mortality by 8-14%.
- ◆ Larger particles (2.5-10 $\mu\text{m}$  and total suspended particles) were not consistently associated with mortality. .





# Animal Experiments

## Godleski et al. (Harvard uni) 1996

### ◆ Air particle concentrator

- process ordinary air, separating it clean, filtered air and air with an excess of fine particles
- 3 clear, sunny days in Boston: temperature 1- 5 C; daily outdoor fine particle (PM 2.5) conc 8-11  $\mu\text{g}/\text{m}^3$

### ◆ Expose rats with bronchitis for 6 hrs/day to either a) the filtered air or b) air with PM2.5 concentrations of approx 288 $\mu\text{g}/\text{m}^3$

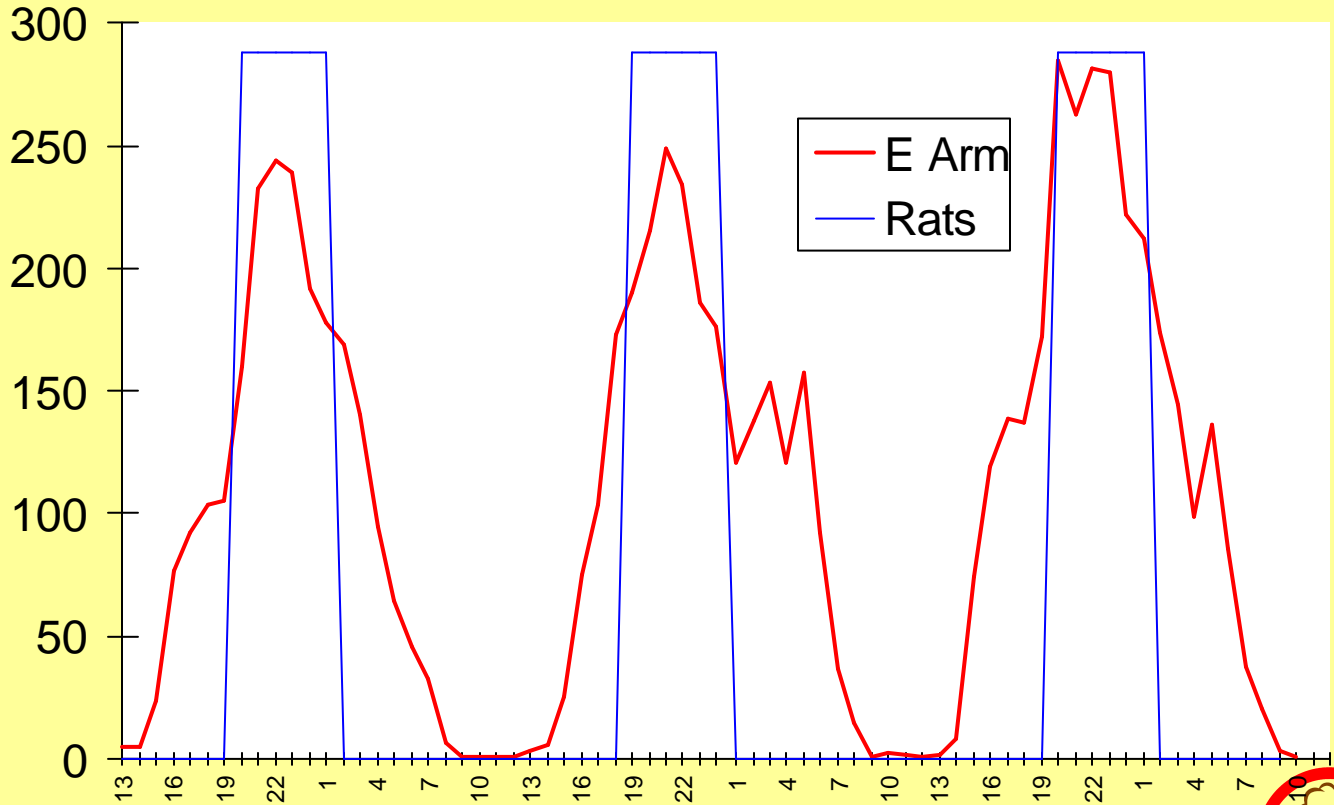


# Harvard - rats study (continued)

- ◆ filtered air: no rats died
- ◆ particles:
  - no visible signs of irritant inhalation such as coughing, rubbing eyes, nose or sneezing
  - significant evidence of broncho-constriction
  - Significantly more neutrophils (white blood cells) in lungs  $6.2 \times 10^4$  (particles) vs  $2.3 \times 10^4$  (filt air)
  - **37% died**



# E Arm Smog 11-14 June vs Rats Exposure (6 hrs @ 30 x Boston air concentration) (PM 2.5s)



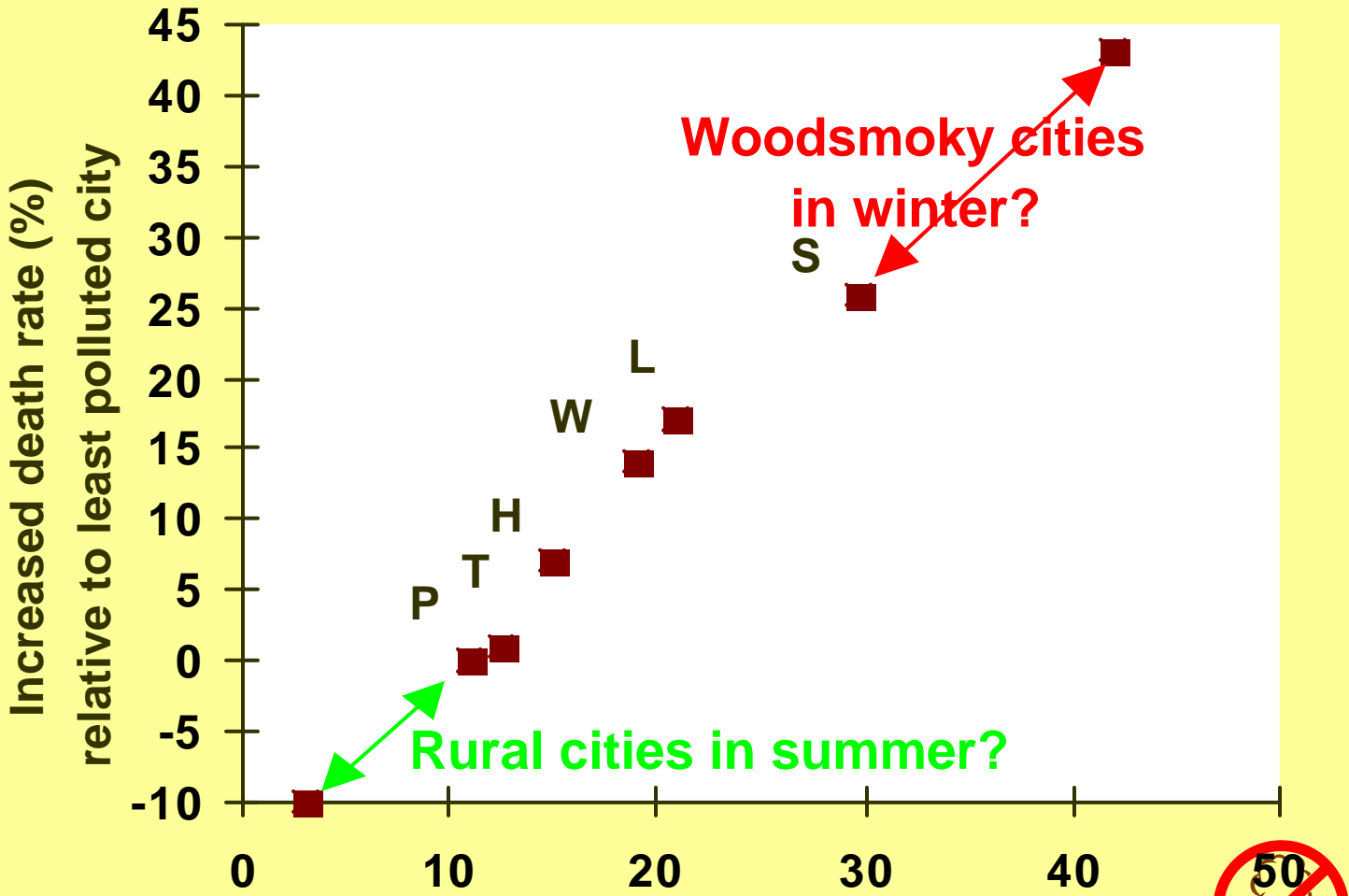
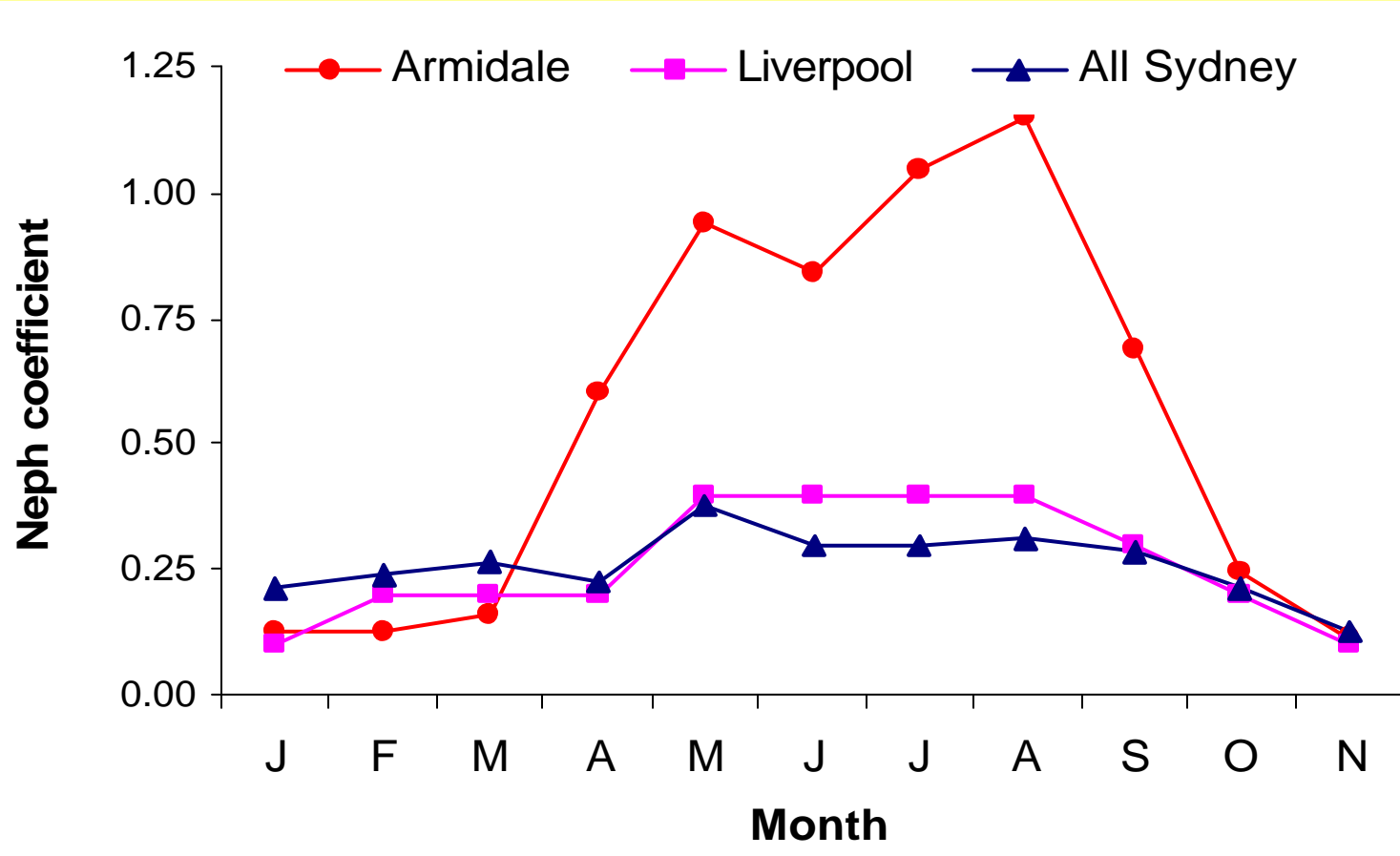


Fig 4. PM2.5 (ug/m3) - 6 US Cities



# Monthly pollution: Armidale & Sydney



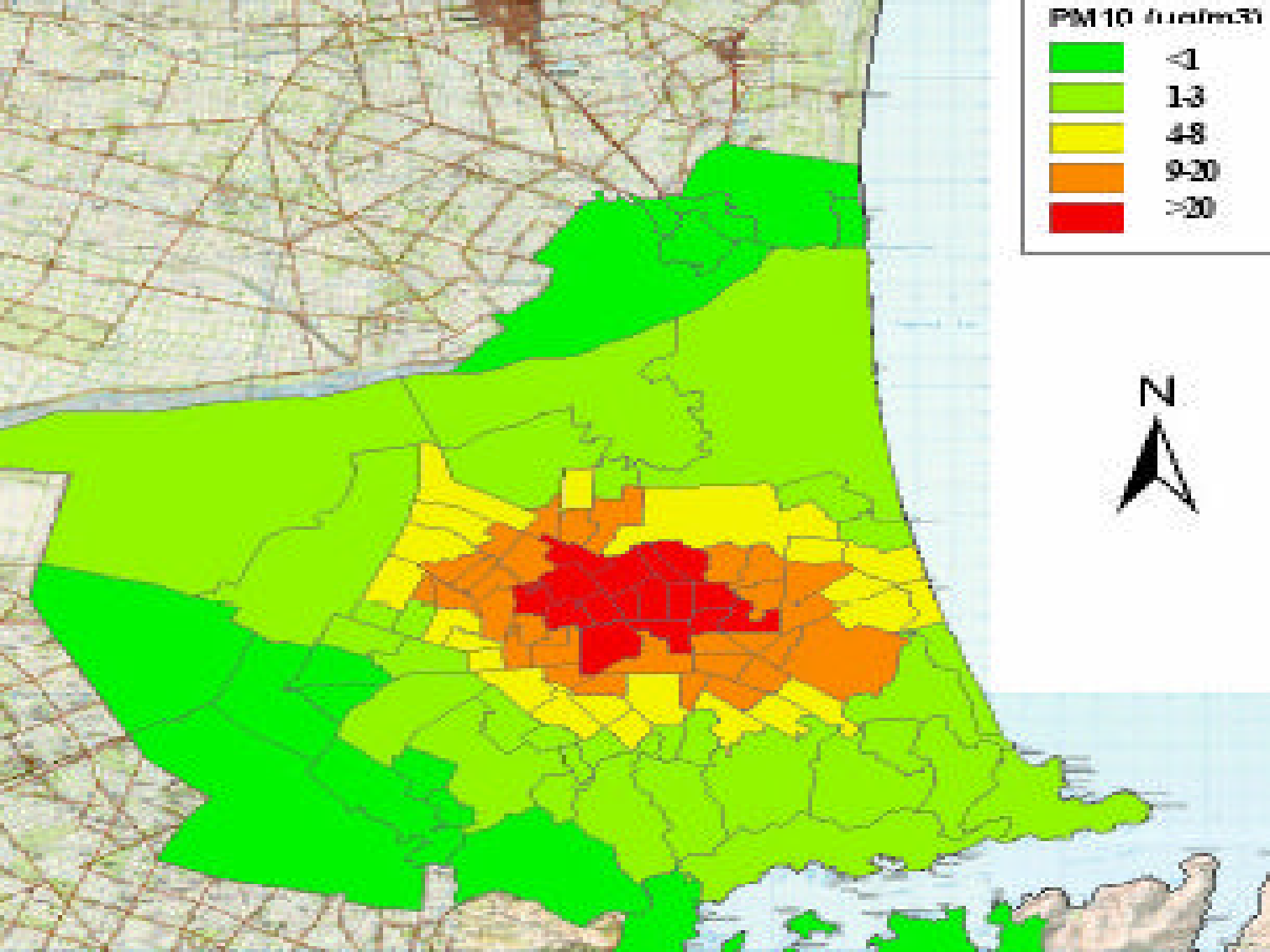
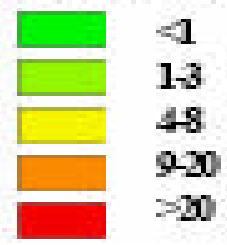
**Health cost of wood smoke:  
most relevant estimate -  
Health and Air Pollution in  
New Zealand: Christchurch Pilot  
Study (31 Aug 05)**

25 Authors

G. Fisher, T. Kjellstrom, A. Woodward, S. Hales, I. Town, A. Sturman, S. Kingham, D. O'Dea, E. Wilton, C. O'Fallon, A. Scoggins, R. Shrestha, P. Zawar-Rewa, M. Epton, J. Pearce, J. Sturman, R. Spronken-Smith, J. Wilson, S. McLeod, R. Dawson, L. Tremblay, L. Brown, K. Trout, C. Eason, P. Donnelly



PM10  $\mu\text{g}/\text{m}^3$



# Estimated effect of air pollution premature deaths per year, Christchurch (pop 333,000)

Source	Premature deaths (no/year)
Domestic heating	124
Industry	18
Diesel vehicles	15.5
Petrol vehicles	0.5





# Estimated cost of illness (\$NZ)

<b>Effect</b>	<b>Cost per case</b>
Mortality	\$750,000
Cancer	\$750,000
Chronic bronchitis	\$75,000
Admission (cardio)	\$3,675
Admission (respiratory)	\$2,700
Restricted activity day	\$150

(NZ\$750,00 = A\$625,000)



# Air pollution: estimated costs (NZ\$mill, annually)

<b>Effect</b>	<b>Domestic</b>	<b>Indust</b>	<b>Vehicle</b>	<b>Total</b>
<b>Mortality</b>	<b>\$93.0</b>	<b>\$13.5</b>	<b>\$12.0</b>	<b>\$118.5</b>
<b>Cancer</b>	<b>\$0.8</b>	<b>\$0.2</b>	<b>\$0.2</b>	<b>\$1.2</b>
<b>Chronic bronchitis</b>	<b>\$2.7</b>	<b>\$0.7</b>	<b>\$0.6</b>	<b>\$4.0</b>
<b>Adission - cardio</b>	<b>\$0.1</b>	<b>\$0.05</b>	<b>\$0.05</b>	<b>\$0.2</b>
<b>Admission - respir.</b>	<b>\$0.4</b>	<b>\$0.1</b>	<b>\$0.1</b>	<b>\$0.6</b>
<b>R'tricted activity days</b>	<b>\$30.0</b>	<b>\$7.0</b>	<b>\$6.0</b>	<b>\$43.0</b>
<b>Minor hospital costs</b>	<b>\$0.15</b>	<b>\$0.03</b>	<b>\$0.02</b>	<b>\$0.2</b>
<b>Total</b>	<b>\$127.0</b>	<b>\$22.0</b>	<b>\$19.0</b>	<b>\$168.0</b>



# Annual cost per solid fuel heater or open fire in Christchurch

- ◆ 8750 open fires and
- ◆ 38184 wood heaters (some mult-fuel)
- ◆ Daily fuel use: fire 14.5, heater 15 kg
- ◆ Real-life emissions: fire 9/kg, heater 13g/kg
- ◆ Total Health costs NZ \$127 million
- ◆ Cost per heater or fire =  
$$127 \text{ million} / (38184 + 8750) = \text{\$NZ}2,700$$



# *Conservative (“at least”) costs*

## ◆ Excludes

- visits to the GPs & medication for minor ailments
- increased risk of cot-death from PM exposure
- genetic damage in babies
- Cost of moving out of polluted areas (perm., or in winter)

## ◆ Death rates = long-term effects of continued exposure

## ◆ Illness = short-term/immediate effect observed within 1-2 days of exposure



# Short vs long-term effects

- ◆ **Long-term effects:** Newcastle/Wollongong - each additional  $10 \mu\text{g}/\text{m}^3$  **annual** PM10 pollution
  - 43% increase in chest colds
  - 34% increase in night-time coughs
- ◆ **Short-term effects:** for each  $10 \mu\text{g}/\text{m}^3$  increase in **daily** PM10 pollution
  - 0.7% to 1.2% increase in respiratory hospital admissions
  - 0.4 to 1.8% increase in child healthcare visits

Current costings may substantially under-estimate the cost of illnesses



# Health costs lead to emissions goals, e.g. Christchurch

Source	<u>tonnes/day (winter)</u>	
	2002	goal (2012)
Residential heating	6.5	0.70
Indust/commercial	0.95	1.1
Motor vehicles	0.94	0.45
<u>Total</u>	<u>8.4</u>	<u>2.3</u>

Reduction in vehicle (mainly diesel) emissions, facilitated by the tightening of emissions limits for new vehicles e.g. 97% reduction in light diesel emissions from 1989-2008

89% reduction in domestic smoke emissions, mainly phasing out older heaters & replacing with non-polluting heating ...



# Goal to be achieved by

- ◆ Replacing 41,980 heaters/open fires
  - 29,600 replaced with non-polluting heating
  - up to 12,380 replaced by another solid fuel burner (including pellet burners)
- ◆ No new wood heaters to be installed
  - except models rated  $< 1.0$  g/kg wood, installed as replacements for more polluting models.
- ◆ Phase out all heaters rated  $> 1.0$  g/kg
  - From 2008 onwards, all heaters rated more than 1.0 g/kg to be removed after 15 years use.



# *Estimated health costs, Australia*

- ◆ Can estimate the cost per kg of PM10/PM2.5 emissions (See, e.g. Robinson, HPJA, Dec 2005)
- ◆ about \$80 (Hobart, Canberra) to \$250 (Sydney)
- ◆ higher estimates (up to A\$1250/kg) in Europe
- ◆ Wood heater, real-life emissions 7 g/kg, 3 tonnes wood per year.
- ◆ Total emissions  $7 \times 3 = 21$  kg
- ◆ Estimated annual health costs: \$1680(Hob) - \$5250 (Syd)





# Wood vs tobacco smoke

- ◆ Wood and tobacco smoke ... similar chemical composition - similar health effects - heart & respiratory diseases, lung cancer (PM2.5 pollution also causes cot deaths, PAHs genetic damage in babies)
- ◆ US EPA study (Ames tests on bacteria, tumor initiation tests on mice) suggests that the lifetime cancer risk from wood smoke may be *12 times* greater than from exposure to an equal amount of cigarette smoke
- ◆ Woodsmoke also reduces the ability of the lungs to fight infection



# *Policies*

- ◆ Should be based on costs and benefits of woodheaters
- ◆ **Costs:** Cost of ill health, cost of measuring air pollution, reduced property values in more polluted areas, cost of education (including ‘targeted education’), increased awareness of health effects may discourage tourism & encourage people to move out
- ◆ **Benefits:** Ambience, can be cheaper than alternatives if people collect their own wood (otherwise dearer)
- ◆ Benefits appear to be substantially less than annual health costs (\$1000s/yr)



# Ideas

- ◆ Promote alternatives such as solar heating
  - Ron Lee's solar heater: materials cost \$1000 Except in morning, saves 80% of heating bills
  - US Dept of Energy plan to create a million solar roofs in the next few years
- ◆ Use renewably-produced biomass for communal wood burning schemes, producing ethanol to replace petrol, even power generation, in preference to in home heaters with real-life emissions  $>0.5$  g/kg





# Recommendations elsewhere

## ◆ American Lung Association

- "individuals should avoid burning wood in homes where less polluting heating alternatives are available"

## ◆ UK Department for Environment, Food and Rural Affairs:

- Avoid burning solid fuels if possible. If you live in a smoke control area, burn only authorised smokeless fuels



# May be more winners than losers

- ◆ Radio phone-in, ABC New England Nov 05
  - Caller said had to move out of Armidale every winter (but hadn't complained to Council)
  - Another caller really glad of the subsidy to replace the heater - new one cheaper to run and warms the house better
  - Others concerned about the effect on wildlife of unsustainable wood harvesting



# Should we

- ◆ Officially recommend people use alternatives where available?
- ◆ Require design of new houses to require least possible heating and discourage/ban wood heaters in new houses?
- ◆ Follow Christchurch's example of phasing out existing heaters (or those with real-life emissions >1.0 g/kg?) after 15 years use?
- ◆ As in Christchurch, require new heater replacing older models to have emissions <1.0 g/kg?



# Should we

- ◆ Adopt a user-pays attitude to wood heating e.g. by a small levy on wood heater use (\$10 per year for pensioners, \$100 per year for other) to cover the cost of managing the pollution problem
- ◆ Use funds for, education, subsidies to insulate buildings, replace heaters and develop better alternatives
- ◆ Solar, combined heat/power, prototype heater - with automatic air control, wood gasifiers





# Final thoughts

- ◆ *"There is no safe level of particulate air pollution"* World Health Organisation
- ◆ National problem - National solutions
- ◆ All Australian cities should meet the PM2.5 standard - annual average  $PM_{2.5} < 8 \text{ ug/m}^3$

