

# **Understanding and responding to the potential health and wellbeing risks associated with unconventional gas mining in Australia**

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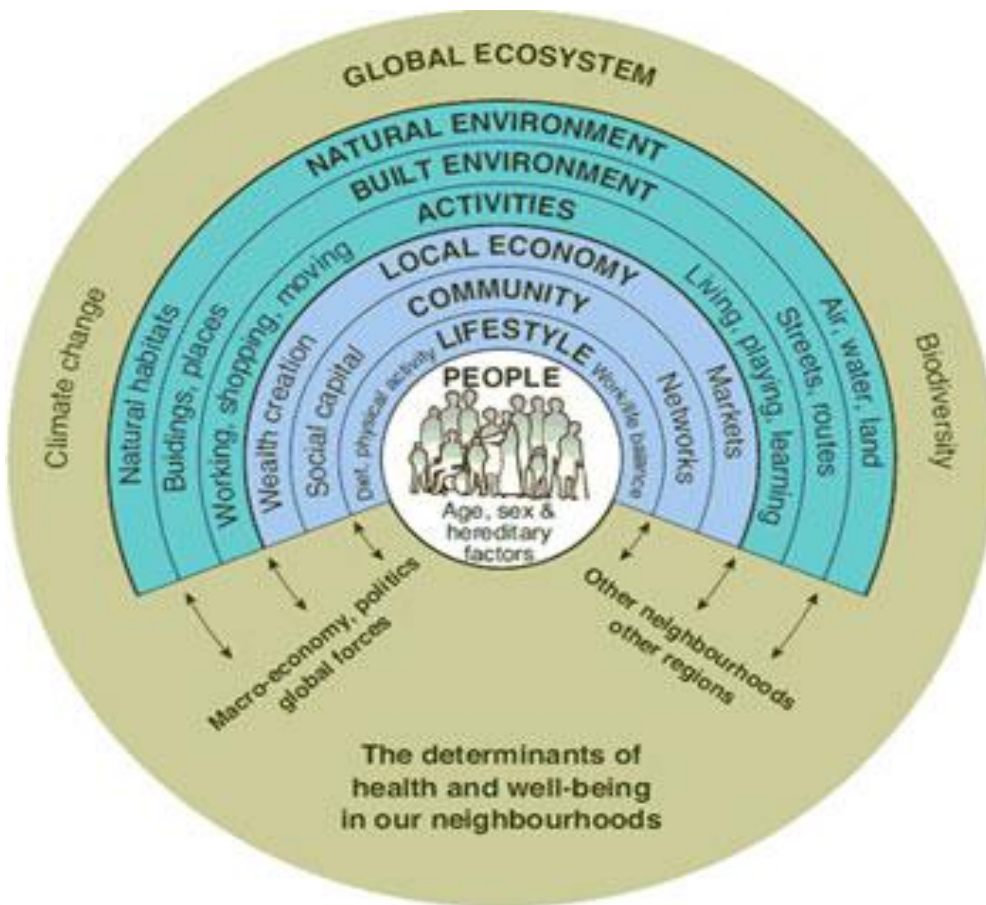


**We acknowledge the Traditional Custodians of the Land on which we meet, and pay respects to Elders past and present...**

**... and reflect that for some 40-60,000+ years these custodians sustained health and life all over this continent of extremes through intimate knowledge of the Australian environment...**



The Environmental Determinants of **Health** ---  
 Good health depends on a working and living environment conducive to both physical & mental wellbeing, including:



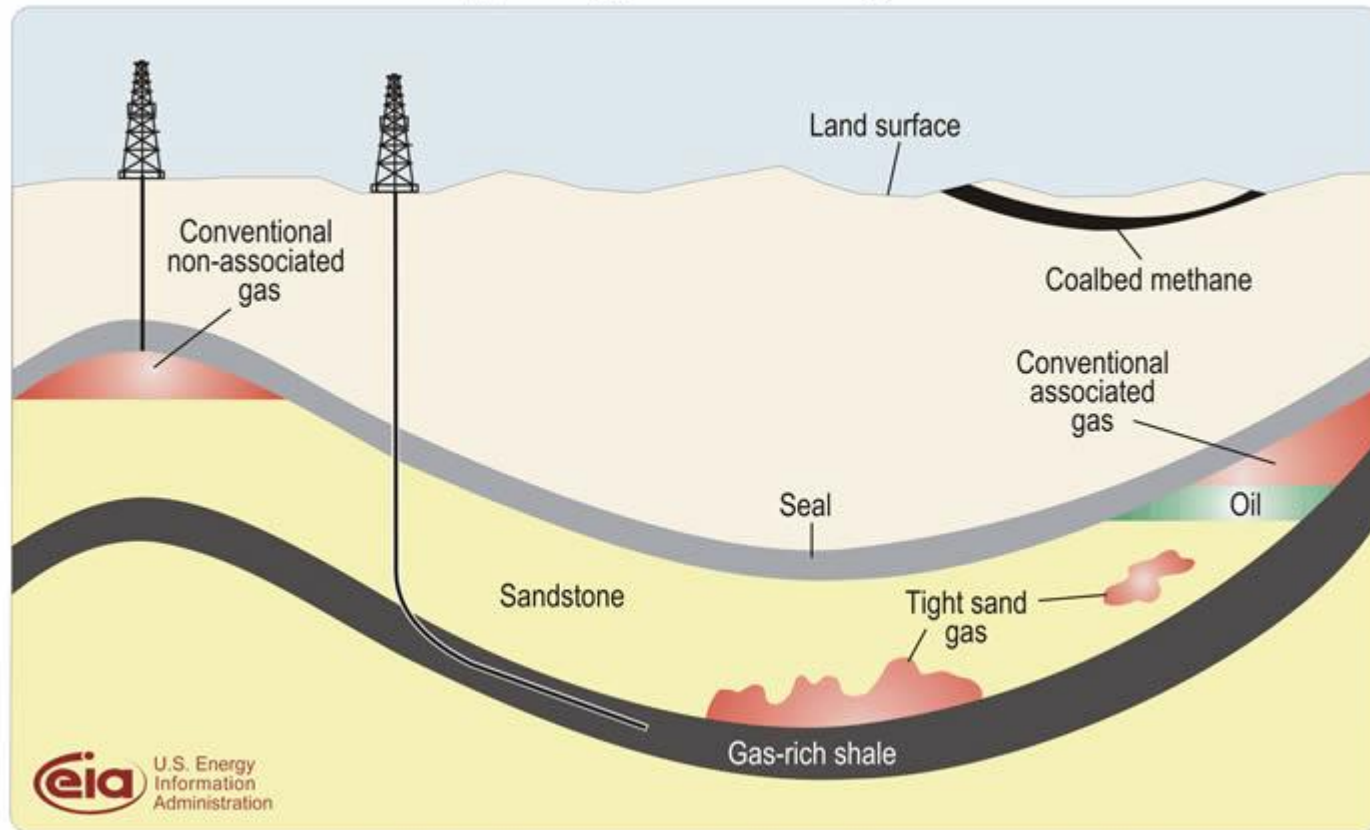
- ***Clean air, protected from harmful pollutants***
- ***Secure supply of safe and sufficient water***
- ***Secure supply of nutritious, safe & affordable food***
- ***Stable and safe climate***
- ***Meaningful livelihood/activities contributing to positive futures***
- ***Resilient and cohesive communities***

# This Presentation

- Provide a brief overview of environmental health studies on unconventional gas mining (mostly from the United States to date)
- Add some key findings of some qualitative research conducted in a rural NSW community
- Ways forward – the precautionary principle?

# What is unconventional gas mining?

Schematic geology of natural gas resources



# Rapid rise in peer reviewed research publications on health and unconventional gas (>685 papers)

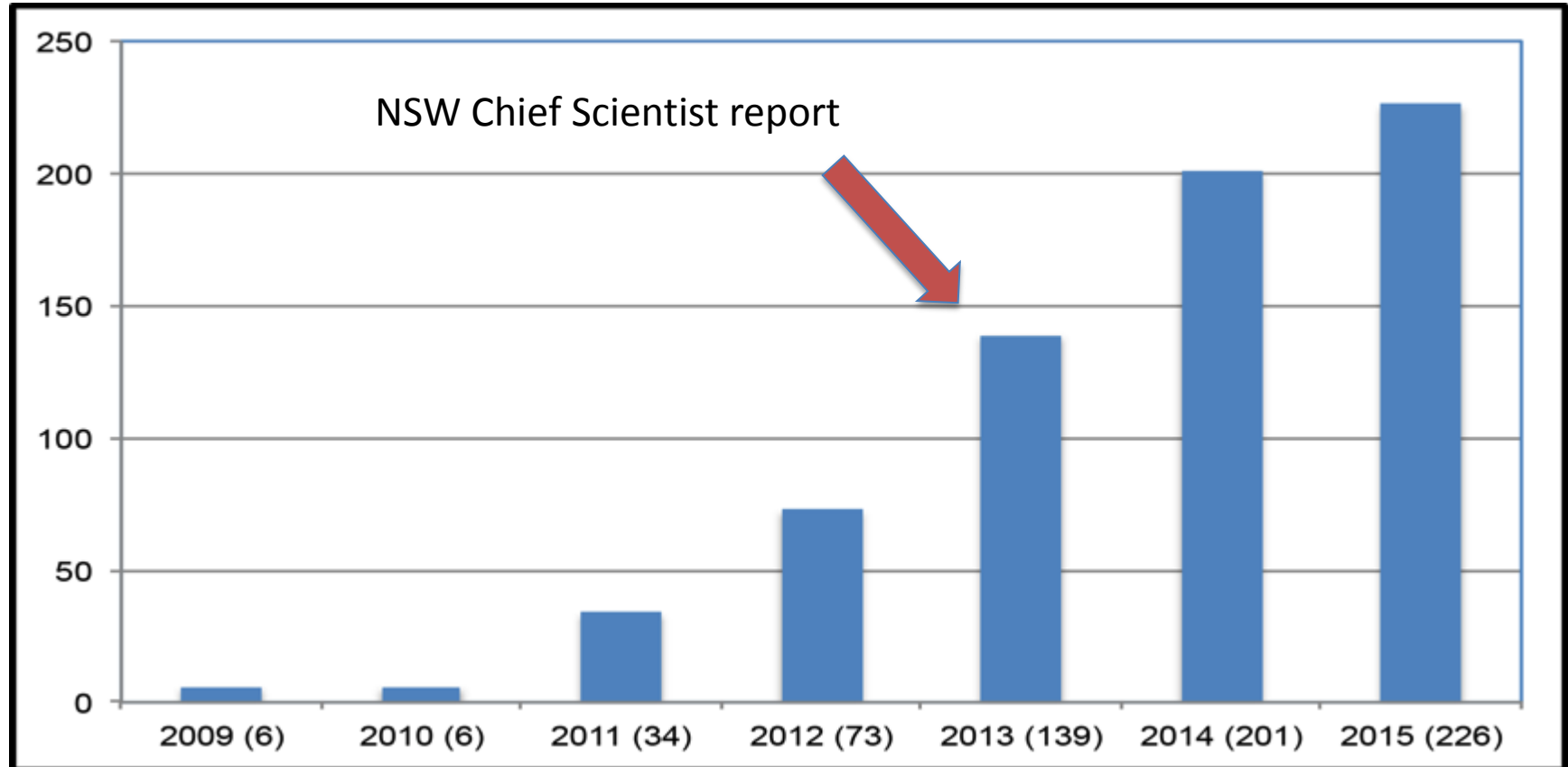


Figure taken from Hays & Shenkoff (2016), Towards an understanding of the environmental and public health impacts of unconventional gas development: a categorical assessment of the peer-reviewed scientific literature, 2009-2015. PLOS One

<http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164>

# Why is evidence from the US particularly important to understanding health impacts?

- Australia's unconventional gas industry is in its infancy. Very little research has been done (no pre, post measurements, small sample sizes, etc.) to understand the impacts on health and wellbeing of affected communities.
- In contrast, an estimated 15.3 million Americans live within a mile of one or more unconventional gas or oil wells (fracked since 2000).
- This has occurred in many states, with varying regulatory regimes and physical and social conditions.
- Research is now building rapidly. This represents an invaluable resource that was not available to many US authorities when the industry began.

# Unconventional gas mining in Australia: situation in 2013 and potential growth

State or territory	Production	Proved reserves	Contingent resources	Prospective resources	Wells drilled
Queensland	264	41 124	Not available	164 000	1 000
NSW	3	284–3 919	527–3 757	14 401	10
Western Australia	none	none	3 275 to 5 898	427 000	15 <sup>(b)</sup>
South Australia	none	none	1 725 to 6 807	45 000 to 268 000	13
Northern Territory	none	none	none	257 276	10
Victoria	none	none	403–1 212	452	none
Tasmania	none	none	none	none	none

(a) Gas potential specified in peta joules.

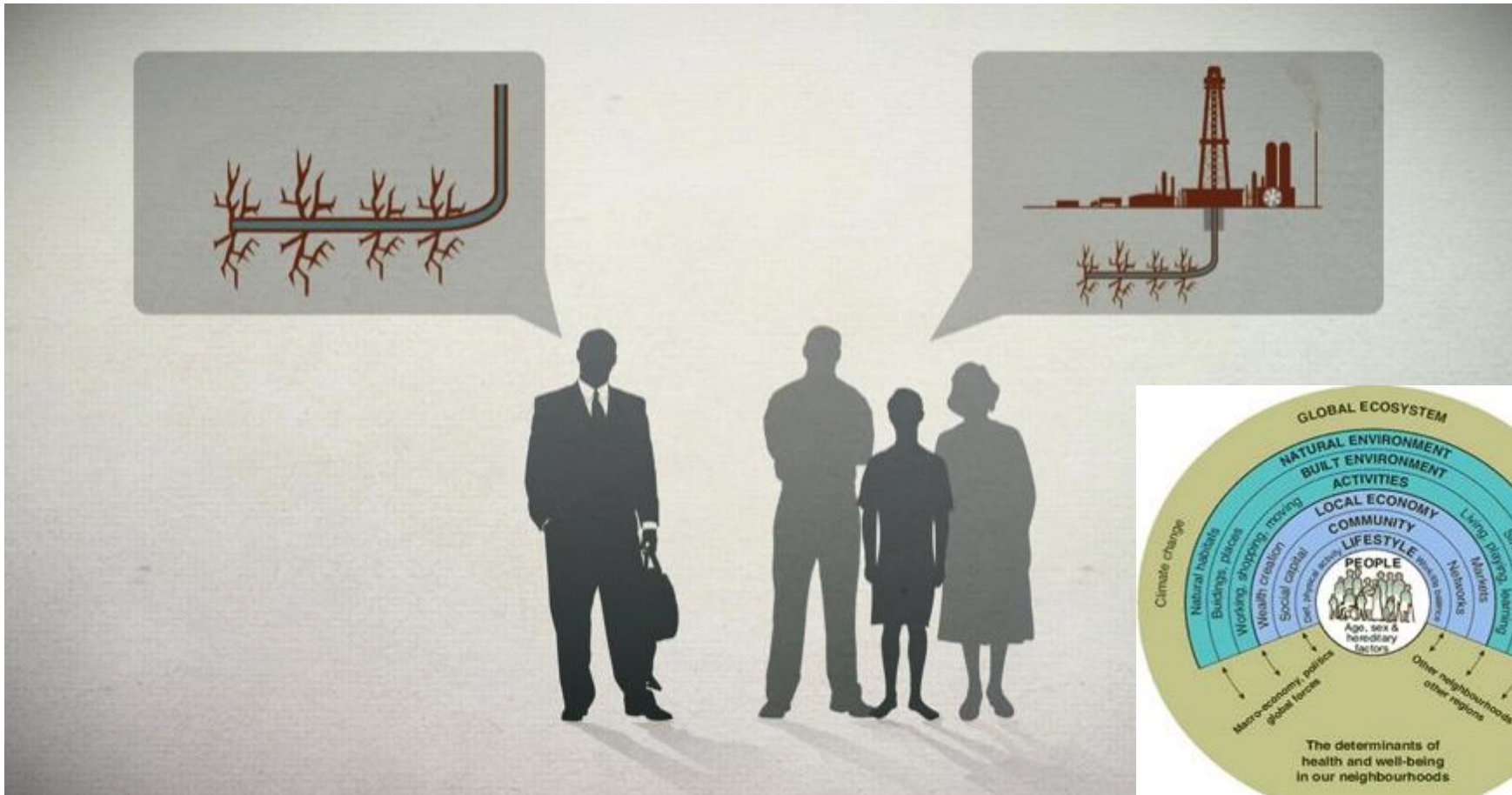
(b) Data were not available for 2013 alone for Western Australia—the 15 wells were drilled between 2005 and 2013.

Note: Where available, the range in the estimates of resources/reserves has been included.

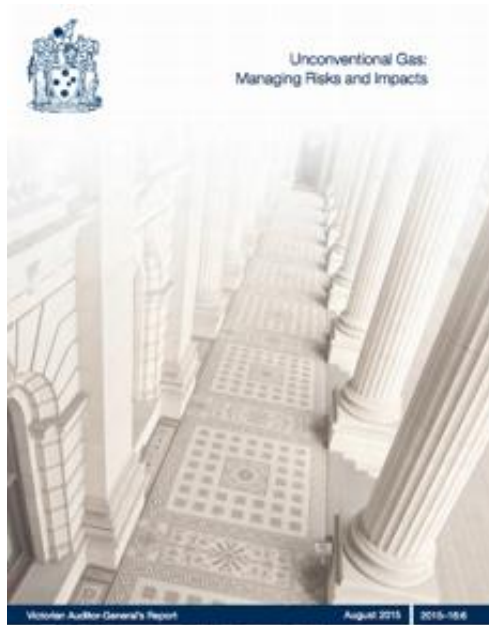
Source: Victorian Auditor-General's Office from the Upstream Petroleum and Resources Working Group Report to the Council of Australian Governments' Energy Council, *Unconventional Reserves, Resources, Production, Forecasts and Drilling Rates*, 2014.



# Fracking is *only one* part of the process that carries health concerns



A risk comparison between shale gas and coal seam gas activities, with and without fracking.



**Figure 2A**  
Potential risks of unconventional gas activities

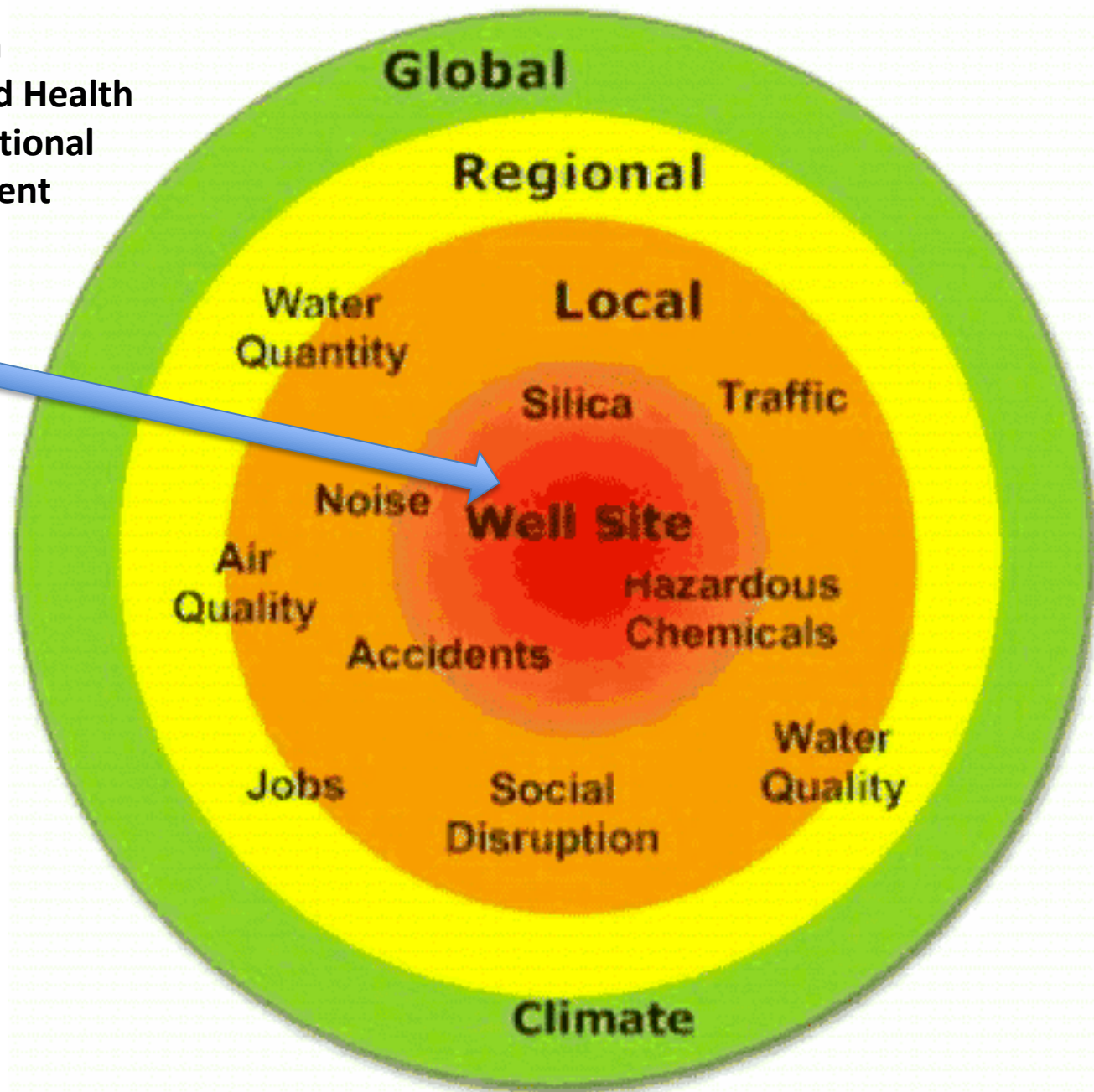
Risk	Type of gas			Potential impacts
	Shale/ tight	CSG		
		Hydraulic fracturing	No fracturing	
<b>Water resource risks</b>				
<ul style="list-style-type: none"> <li>Water usage</li> </ul>	✓	✓	✗	Decreased groundwater quantity available for other uses
<ul style="list-style-type: none"> <li>Produced water</li> </ul>	✗	✓	✓	Pollute surface waters, groundwater, soils, food and livestock
<ul style="list-style-type: none"> <li>Flowback water</li> </ul>	✓	✓	✗	Pollute surface waters, soils, food and livestock
<ul style="list-style-type: none"> <li>Disposal of produced solids</li> </ul>	✓	✓	✗	Pollute soils, surface water and groundwater
<b>Groundwater contamination from fracking</b>				
<ul style="list-style-type: none"> <li>Fracking fluid leakage from poor well design, construction and integrity</li> </ul>	✓	✓	✗	Pollute groundwater—impact irrigation, stock and drinking water quantity and quality
<ul style="list-style-type: none"> <li>Chemical contamination from poor storage and surface spills of fracking chemicals</li> </ul>	✓	✓	✗	Pollute groundwater—impact irrigation, stock and drinking water quantity and quality
<ul style="list-style-type: none"> <li>Chemical contamination through leakage of fracking chemicals and flowback water into fracking cracks</li> </ul>	✓	✓	✗	Pollute groundwater—impact irrigation, stock and drinking water quantity and quality
<ul style="list-style-type: none"> <li>Natural gas released or disturbed by fracking might seep into groundwater aquifers and other wells</li> </ul>	✓	✓	✓	Pollute groundwater—impact irrigation, stock and drinking water quality and quantity
<ul style="list-style-type: none"> <li>Disposal of used fracturing fluid, produced water or waste products</li> </ul>	✓	✓	✗	Pollute groundwater, surface water and other wells.

Risk	Type of gas			Potential Impacts
	Shale/ tight	CSG		
		Hydraulic fracturing	No fracturing	
<b>Air contamination from wells and infrastructure</b>				
• Point source methane released from a well, leak in a pipeline or plant equipment	✓	✓	✓	Impact amenity and human health and climate change impacts
• Fugitive emissions from fractures and cracks in the ground	✓	✓	✓	Pollute groundwater quality and impact vegetation and climate change impacts
• Fracturing fluid can contain volatile organic compounds (VOCs) which can be released into the atmosphere	✓	✓	x	Impact amenity and human health
• Naturally occurring contaminants and radioactive materials in groundwater can be brought to the surface through drilling	✓	✓	✓	Pollute soils, surface water, stock and create prescribed wastes
• Drilling equipment and trucks produce emissions	✓	✓	✓	Impact amenity and human health
<b>Landscape impacts from surface infrastructure or seismic surveys</b>				
• Scale of footprint on landscape	✓	✓	✓	Impact landscape and biodiversity values, habitat fragmentation and community amenity, decreased land values
• Vegetation removal	✓	✓	✓	Impact biodiversity values, habitat fragmentation and soil quality
<b>Seismic activity</b>				
• Seismic activity from aquifer injection	N/A	✓	N/A	Impact landscape and biodiversity values
• Seismic activity from hydraulic fracturing	✓	✓	x	Impact landscape and biodiversity values
<b>Operational activities</b>				
• Noise	✓	✓	✓	Impact amenity and human health
• Dust	✓	✓	✓	Impact amenity and human health
• Increased infrastructure	✓	✓	✓	Impact amenity
• Increased traffic and population	✓	✓	✓	Impact amenity
<b>Well integrity</b>				
• Well leakage	✓	✓	✓	Pollute groundwater – impact irrigation, stock and drinking water quality
• Well blowouts	✓	✓	✓	Pollute surface and groundwater – impact irrigation, stock and drinking water quantity and quality
• Abandoned wells	✓	✓	✓	Pollute groundwater – impact irrigation, stock and drinking water quantity and quality
<b>Depressurisation of the coal seam</b>				
• Changes in pressures of adjacent aquifers	x	✓	✓	Impact groundwater availability
• Reductions in surface water flows in connected systems	x	✓	✓	Impact surface water availability
• Land subsidence over large areas	x	✓	✓	Impacts surface water systems, ecosystems, irrigation and grazing lands

Source: Victorian Auditor-General's Office.

**Potential Public Health  
Hazards, Exposures and Health  
Effects from Unconventional  
Natural Gas Development**

**Concerns for  
Workers Health**



[John L. Adgate \\*†](#),  
[Bernard D. Goldstein](#)  
[‡](#), and [Lisa M.](#)  
[McKenzie †](#)

*Environ. Sci. Technol.*,  
2014, 48 (15), pp  
8307–8320

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American Chemical  
Society

# Six main areas of unresolved concerns to public health

1. Water concerns
2. Air pollution concerns
3. Psychological and social wellbeing, land competition
4. Negative health outcomes associated with living close to wells
5. Uncertainty about protective regulation
6. Methane emissions and climate change

# 1. Water pollution concerns, no proven long-term solution to the massive waste disposal challenge



# Waste Water Concerns

Millions of litres of produced water containing a wide range of naturally occurring and introduced chemicals that may be harmful to human health are brought to surface from shale and coal beds through unconventional gas operations.

Methods for handling and disposal of huge volumes of contaminated water remain problematic. Adequacy of water treatment processes in removing all potential toxins is unclear.

Evaporation ponds are vulnerable to spills and leaks and there is no long-term solution for disposing the resulting highly concentrated chemical mixtures.

Uncertainty surrounds health risks associated with added chemicals and substances in drilling and fracking fluids, as well as naturally occurring substances due to lack of assessment and problematic disclosure.

Naturally occurring chemicals of concern include heavy metals, volatile organic compounds, polyaromatic hydrocarbons, radioactive materials (NORMs), endocrine disrupting chemicals

Surface water and aquifer contamination from accidents and faulty equipment have already occurred in Australia.

[https://www.epa.gov/sites/production/files/2015-07/documents/hf\\_es\\_erd\\_jun2015.pdf](https://www.epa.gov/sites/production/files/2015-07/documents/hf_es_erd_jun2015.pdf)

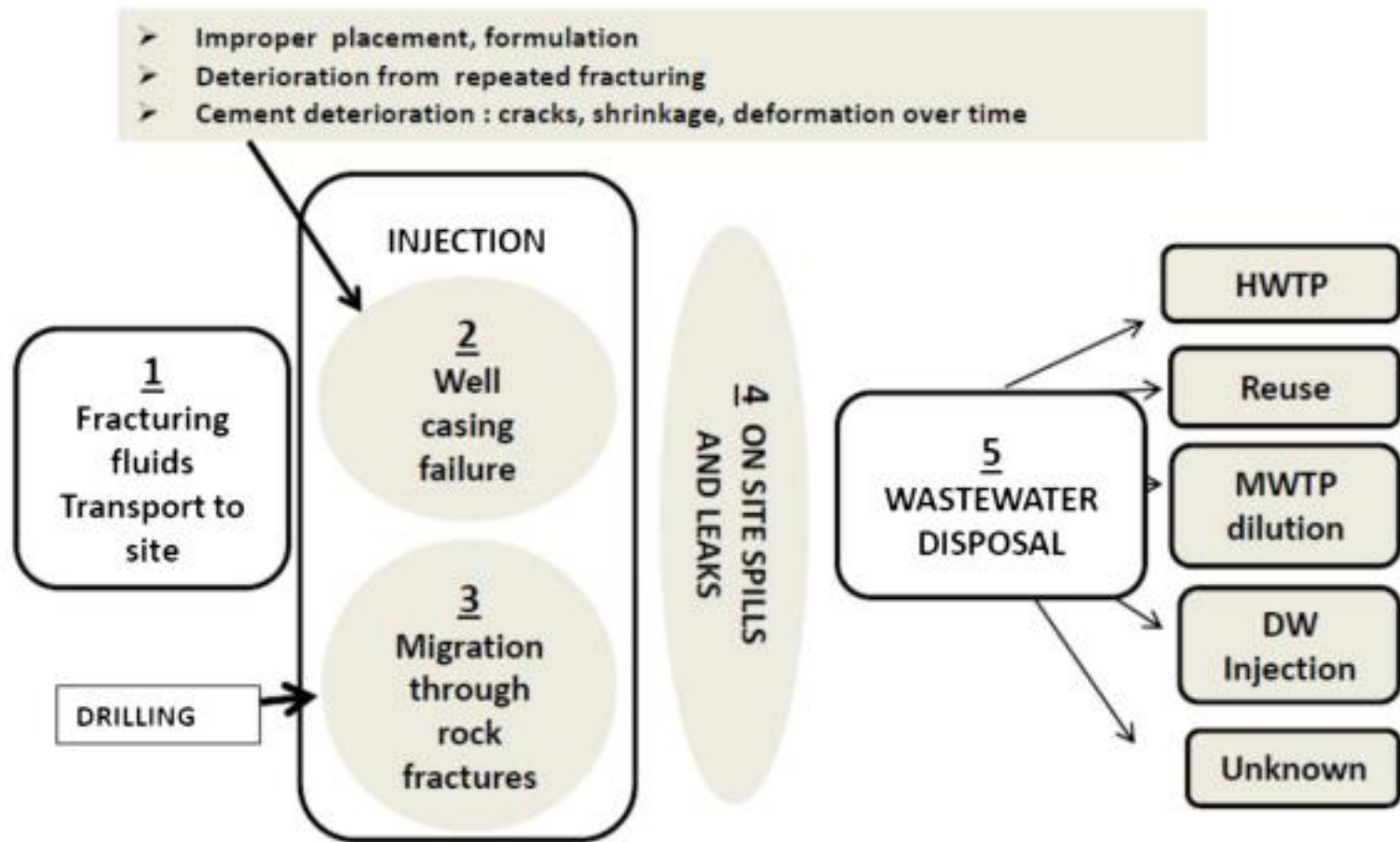


Figure 2. Contaminant pathways in shale gas development (after Rozell & Reaven 2011).

Rozell DJ, Reaven SJ. 2011. Water pollution risk associated with natural gas extraction in Marcellus Shale. Risk Analysis. 1539–6924



# Summary of the literature on Water Quality

*Of 58 original research studies on shale gas operations and water quality, “40 (69%) have findings that indicate potential, positive association or actual incidence of water contamination..., while 18 studies (31%) have findings that indicate minimal potential, no association, or rare incidence of water contamination”.*

Hays, J., Shonkoff, S. (2016). Toward an understanding of the environmental and public health impacts of conventional natural gas development: a categorical assessment of the peer-reviewed scientific literature, 2009-2015. PLOS One, April 20, 2016;  
<http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164>

## **2. Air pollution is an under-recognised but important potential health risk**

- Methane**
- BTEX chemicals/Volatile organic compounds**
- NO<sub>x</sub>, Hydrogen Sulfide, Formaldehyde**
- Diesel fumes, Particulate Matter, fine silica**
- Ground level Ozone**

David Brown\*, Beth Weinberger, Celia Lewis and Heather Bonaparte

# Understanding exposure from natural gas drilling puts current air standards to the test

Recent and projected growth in the oil and gas production sector has underscored the need for EPA to gain a better understanding of emissions and potential risks from this industry sector. Harmful pollutants emitted from this industry include air toxics such as benzene, toluene, ethylbenzene, and xylene; criteria pollutants and ozone precursors such as  $\text{NO}_x$  and VOCs; and greenhouse gases such as methane. These pollutants can result in serious health impacts such as cancer, respiratory disease, aggravation of respiratory illnesses, and premature death. However, EPA has limited directly-measured air emissions data on criteria and toxic air pollutants for several important oil and gas production processes. [These] limited data, coupled with poor quality and insufficient emission factors and incomplete NEI data, hamper EPA's ability to assess air quality impacts from selected oil and gas production activities.

– US Environmental Protection Agency  
(EPA) Office of Inspector General (1)

# Summary of the literature on Air Pollution

A literature analysis conducted by Hays & Shonkoff found that, *“of 46 peer-reviewed publications arising from original research, 40 (87%) reported that unconventional gas developments increased air pollution emissions and/or atmospheric concentrations”, while 6 (12%) reported no such indications.*

Hays, J., Shonkoff, S. (2016). Toward an understanding of the environmental and public health impacts of conventional natural gas development: a categorical assessment of the peer-reviewed scientific literature, 2009-2015. PLOS One, April 20, 2016; <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164>

# 3. Evidence-based Concerns

## Psycho-social and economic impacts

- Distress and division within and between families and communities through polarising into for and against/ winners and losers.
- Solastalgia from industrialisation of landscapes.
- Disturbances from lights, noise, traffic, reduced property values, fear, etc. for those living nearby.
- Local, regional and broader unfavourable economic changes

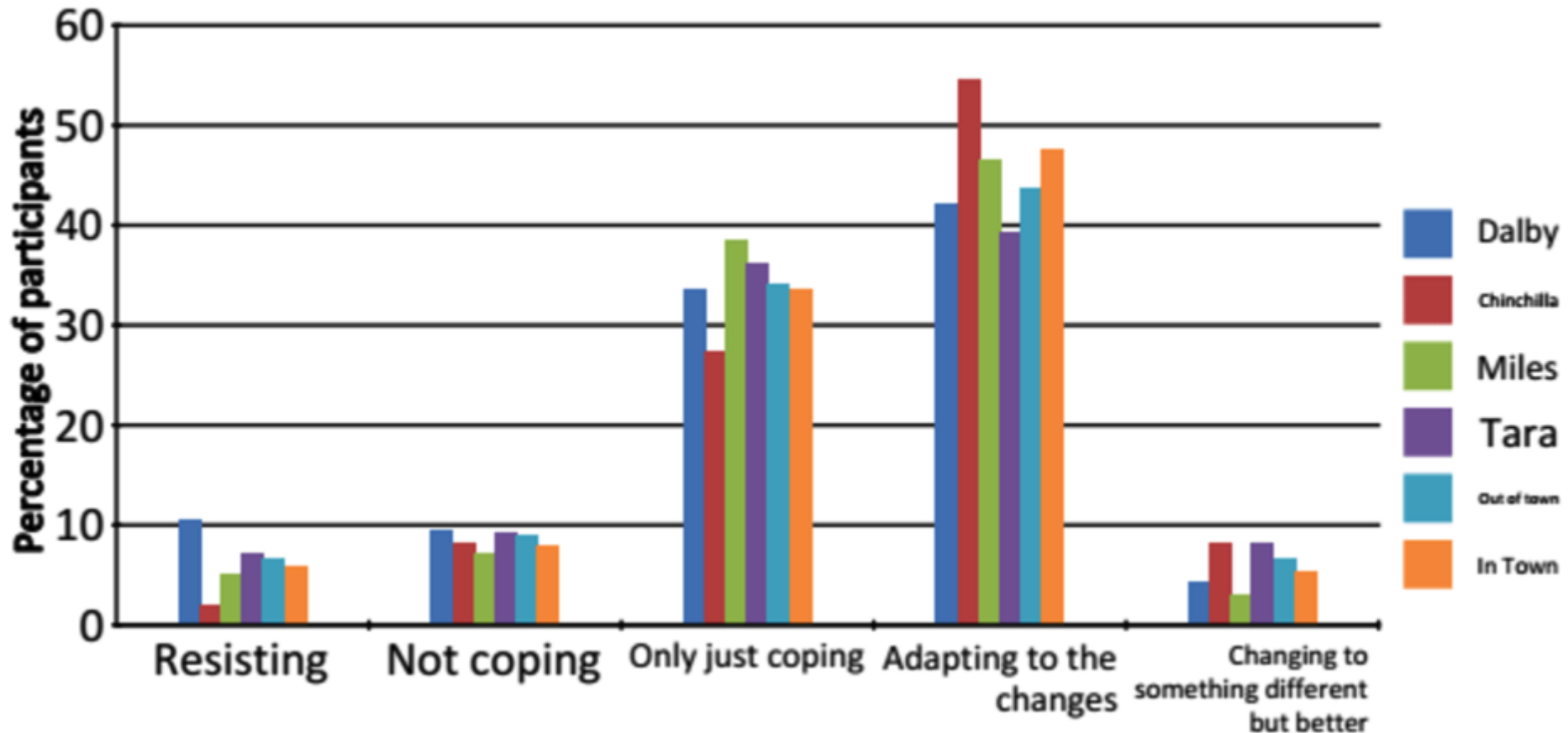
All these factors can contribute to reduced mental health, and increase the risk of depression and anxiety, that can also contribute to other physical health problems.

**CSIRO survey of Community  
Wellbeing and responding  
to change:**

Western Downs region in Queensland  
Andrea Walton, Rod McCrea and  
Rosemary Leonard September 2014

## Community response

In response to questions around how residents felt their community was dealing with CSG development in their region, about 48.5% felt that their community was struggling with the changes - either “resisting”, “not coping”, or “only just coping”. While 45.6% indicated their community was adapting, less than 10% in every community felt that the changes were to something different but better. Those who moved away from the area are not included.



# Psychosocial experiences associated with preparations for CSG mining in a rural NSW community

- Melissa Haswell, Anna Bethmont, Steve Robinson and Jan Ritchie
- The team was invited by members of the community and the study was approved by Council because of concerns about people's mental health and wellbeing.
- Qualitative study using maximum variation sampling to explore range of experiences across the community.



# Quick Summary of experience: two multigenerational farmers, who consented to have exploration wells drilled on their property

## Farmer One –

- *[The company] approached us to put a well on our property. They spent an enormous amount of money on the roads, where we wanted them. They drilled and fracked the wells and paid us extremely well for that. Its only a small area, 80x80 metre pad. Normally they remove them after drilling and fracking, but we asked them to keep it there to stack silage on it.*
- *We protested one well too close to the house, they said no problem, sited the road exactly where I wanted it, no questions asked.*
- *[The disturbance] was no worse than a major railway event... they tell you well in advance... water cart on the road all the time so there's no dust. It was a 24 hour operation but we knew it was happening. The road was very close to our home, so they had a 10km/hr speed limit.*

## Second Farmer –

- *Very similar. Massive traffic for the first pad, cars and trucks with the fracking, but only for about one week, worth it for the thousands of dollars I was paid. Such a short period of time, then its pulled back to about two care spaces. They left the pad there - \$50,000 worth of gravel for hay and fertiliser.*

# Strong confidence that farmers can say no

- *And that's the way its gotta be for the simple reason, [the company]'s got it in their things, that if I own a farm and they want to put a gas well on it and I say no, you're not gonna put it on my place – they don't come.*
- *You can't get much fairer than that – if I don't want it on my place, I can say no and you can't come.*

# Experience of a farm family who did not consent for activities on their property

Slow recognition of what living close to gas fields means

- *They started to drill a few wells - we didn't really concern ourselves too much about it because we really didn't know too much about what was going on. They drilled a few wells, they weren't up here... we figured it probably wasn't going to affect us really...when AGL bought it and then they suddenly - then they started talking about, "Well, the gas field's going to go from \*\* through to \*\* Road. We thought, "Well, we're all in this now".*

Panic sets in

- *And then when the maps came out, you'd see your square of property and there'd be all these grid lines on it and all these dots, and you'd think, "They're all the - they're going to be all the wells", and I suppose **that's when panic started to set in** when you see how many wells there are and you see the actual dots, even though they say they were 'indicative dots'. And to this day they've never actually told us where the wells are going to go.*

Angry at the 'power over' attitude, inability to say no

*The battle existed because I said to them, "Look as far as I'm concerned your surveying my land. I'm not giving you permission... If you want permission then we need to organise a whole agreement to do that", and their attitude is, "We're flying over it. We can do what we like. You don't count".*

Anger that rural protocols on the farm were not respected

*There were steel pegs on the ground... they would shut and open the gates, but ... this car comes in behind and sees the gate open, so the gate never gets shut... So they said they won't - cattle won't get mixed up, it'll be fine... we had cattle in different paddocks all the time from them, and ... there'd be lolly paper and orange skins left where the car was left, and they would just drive off*

The lights

*Because we're angry and a bit anxious, you wake up in the night, look out my bathroom window to go to the toilet and you could see these lights shining in your face, so how can you go back to sleep after you've seen all these lights when you don't want them there to begin with? And then we'd get, this local lady that worked for them come and tell us, you know, that, "They'll move - they'll put barriers up and they'll do this, and there's no need to worry", yet she goes home to her house on the other side of town and I'm stuck here in this house looking at them drilling these three wells.*

# Feeling Attacked and Overwhelmed

- *“The impact is becoming aware of the reality of what's going on around you. That takes a huge emotional and physical toll because you suddenly realise that, you know you don't just have to go to work and earn a dollar to feed your family. You've actually got a fight on your hands as well, this other really big fight that's threatening the way you live, an asset that you've worked all your life to save up for, and it's a direct attack on your, sometimes it's your values but it's certainly your lifestyle.”*

# Turning the conflict inward

- *In lots of ways it's torn the community into two camps.*
- *You keep telling people, it's a great community, but it no longer is... everybody knows you, everybody talks to you, smiles, you know? And it's no longer like that.*
- *I hate to see [the community] go through what it's going through. I moved here because initially just before coal got here it was a wonderful place to raise your kids and now it's being divided, it's been split, it's got anger and it's got abuse and all sorts of things going on that's scaring a lot of people.*
- *I think it's a really significant issue that's impacting on lots of people's lives. It's not tearing us in half. It's just a really significant thing we've got to deal with and some people have been more affected than others and it's not going to rip [the community] in half, but it's certainly having an impact and a major impact on some people's lives more than others.*



Photo by Moira McDade  
<https://creativecommons.org/licenses/by/2.0/>

1-1-2013

## The Economic Contest Between Coal Seam Gas Mining and Agriculture on Prime Farmland: It May Be Closer than We Thought

Cindy Chen  
*University of Sydney*

Alan Randall  
*University of Sydney*

### **Abstract**

There is substantial market impetus behind the expansion of coal seam gas (CSG) in Australia, driven by buoyant international demand for liquefied natural gas. The benefits of CSG development come in the first few decades, followed by a potentially long period in which the agricultural and environmental costs dominate. We identify the key drivers influencing the economic contest of CSG versus agriculture on prime farmland, and undertake a Darling Downs case study using evidence from primary and secondary sources. Despite the momentum driving CSG development, under some plausible scenarios, the long-term economic net benefits from agriculture-only exceed those from CSG-only and CSG-agriculture coexistence.

This study questions the long term economic benefits of CSG and co-existence over agriculture alone.

Note:

Health and social costs are not considered in this analysis.



4. Studies reporting associations  
between unconventional gas  
developments and negative human  
health impacts

# Three published studies reporting negative birth outcomes linked to well proximity and/or density

Lower mean birth weight and higher frequency of small for gestational age (OR 1.34 (95% CL 1.10-1.63))

- Stacy SL, Brink LL, Larkin JC, Sadovsky Y, Golstein, BD, Pitt EO, et al. Perinatal outcomes and unconventional natural gas operations in Southwest Pennsylvania. PLoS ONE. 2015; 10:e0126425 doi: 10.1371/journal.pone.0126425

Preterm birth (OR 1.4(95% CL 1.0-1.9) & high risk pregnancy (OR 1.3 (95% CL 1.1-1.7)

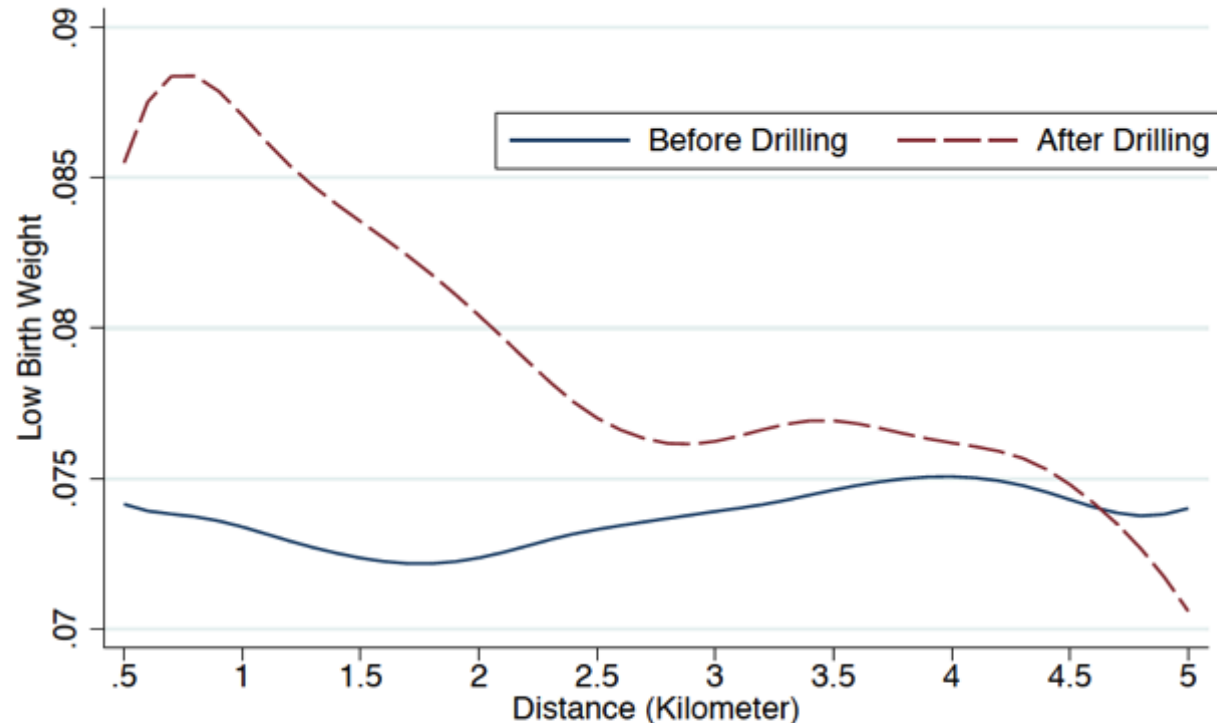
- Casey JA, Savitz DA, Rasmussen SG, Ogburn EL, Pollak J, Mercer DG, et al. Unconventional natural gas development and birth outcomes in Pennsylvania, USA. Epidemiology 2015; in press.

Birth defects (congenital heart defects (OR 1.3 (95%CL 1.2-1.5)), neural tube defects (OR 2.0, (95% CL 1.0-3.9)) but slightly higher birth weight nearer wells

- McKenzie LM, Guo R, Witter RZ, Savitz DA, Newman LS, Adgate JL. Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. Environmental Health Perspectives 2014; 122(4): 412-417.

# Research Presented by Dr Elaine Hill

Reduced birthweights associated with closeness to wells  
(avg reduction of 48.5g) (increased % of low birth weight)



Results from a local polynomial regressions (bandwidth=0.1 km) of low birth weight on distance from closest well's future/current location. Source: Author calculations from Pennsylvania Department of Health Vital Statistics.

# Increased hospitalisation rates in postcodes associated with density of wells

*Cardiology inpatient prevalence rates were significantly associated with number of wells per zip code ( $p < 0.00096$ ) and wells per  $\text{km}^2$  ( $p < 0.00096$ ) while neurology inpatient prevalence rates were significantly associated with wells per  $\text{km}^2$  ( $p < 0.00096$ ). Furthermore, evidence also supported an association between well density and inpatient prevalence rates for the medical categories of dermatology, neurology, oncology, and urology. (Abstract)*

Jemielita T. et al. (2015) Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates. PLoS ONE 10(7): e0131093.doi:10.1371/journal.pone.0131093

# Newest study in JAMA: exacerbation of asthma attacks assoc with well activity

JAMA Intern Med. 2016 Jul 18. doi: 10.1001/jamainternmed.2016.2436. [Epub ahead of print]

## **Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations.**

Rasmussen SG<sup>1</sup>, Ogburn EL<sup>2</sup>, McCormack M<sup>3</sup>, Casey JA<sup>4</sup>, Bandeem-Roche K<sup>2</sup>, Mercer DG<sup>5</sup>, Schwartz BS<sup>6</sup>.

### **Key Points**

**Question** Is there an association between unconventional natural gas development (UNGD) and asthma exacerbations?

**Findings** In this nested case-control study of 35 508 patients with asthma, those in the highest quartile of residential UNGD activity had significantly higher odds of 3 types of asthma exacerbations (new oral corticosteroid medication orders, emergency department visits, and hospitalizations) than those in the lowest quartile.

**Meaning** UNGD activity near patient residences was associated with increased odds of mild, moderate, and severe asthma exacerbations.

Table 2. Associations of Unconventional Natural Gas Development Activity Metrics and Asthma Outcomes<sup>a</sup>

Activity Metric <sup>b</sup>	Odds Ratio (95% CI)		
	Asthma Hospitalizations	Asthma Emergency Department Visits	OCS Orders
Pad			
Low	1.26 (1.06-1.50)	1.53 (1.06-2.23)	1.54 (1.37-1.74)
Medium	1.37 (1.15-1.64)	1.77 (1.2-2.6)	1.66 (1.47-1.87)
High	1.45 (1.21-1.73)	1.37 (0.94-1.99)	1.59 (1.41-1.81)
Spud			
Low	1.16 (0.98-1.37)	1.53 (1.06-2.21)	1.45 (1.29-1.63)
Medium	1.26 (1.05-1.50)	1.54 (1.04-2.27)	1.98 (1.75-2.24)
High	1.64 (1.38-1.97)	1.57 (1.08-2.29)	1.99 (1.75-2.26)
Stimulation			
Low	1.13 (0.96-1.33)	1.51 (1.05-2.19)	1.23 (1.09-1.39)
Medium	1.31 (1.10-1.57)	1.74 (1.17-2.61)	2.22 (1.95-2.53)
High	1.66 (1.38-1.98)	1.71 (1.16-2.52)	3.00 (2.60-3.45)
Production			
Low	1.10 (0.92-1.30)	1.47 (1.01-2.14)	1.28 (1.13-1.46)
Medium	1.16 (0.97-1.38)	1.10 (0.74-1.65)	2.15 (1.87-2.47)
High	1.74 (1.45-2.09)	2.19 (1.47-3.25)	4.43 (3.75-5.22)

Abbreviation: OCS, oral corticosteroid.

<sup>a</sup> Multilevel models with a random intercept for patient and community were adjusted for age category (5-12, 13-18, 19-44, 45-61, 62-74,  $\geq 75$  years), sex (male or female), race/ethnicity (white, black, Hispanic, or other), family history of asthma (yes vs no), smoking status (never, former, current, or missing), season (spring, March 22-June 21; summer, June 22-September 21; fall, September 22-December 21; winter, December 22-March 21), Medical Assistance (yes vs no), overweight/obesity status (normal, body mass index [BMI],  $< 85$ th percentile for children or  $< 25$  for adults; overweight, BMI, 85th to  $< 95$ th percentile for children or 25 to  $< 30$  for adults; obese, BMI,  $\geq 95$ th

percentile for children or  $\geq 30$  for adults; or BMI missing), type 2 diabetes (yes vs no), community socioeconomic deprivation (across quartiles), distance to nearest major and minor arterial road (truncated at the 98th percentile, measured in meters, z transformed), squared distance to nearest major and minor arterial road (truncated at the 98th percentile, measured in meters, z transformed), maximum temperature on the day prior to event (measured in degrees Celsius), and squared maximum temperature on the day prior to event (measured in degrees Celsius).

<sup>b</sup> For all activity metrics, very low activity was the reference group.

# Of 31 studies, 26 (84%) reported negative public health impacts associated with living closer to unconventional gas developments

Hays J, Shonkoff SBC (2016 PLoS ONE 11(4): e0154164. doi:10.1371/journal.pone.0154164  
<http://journals.plos.org/plosone/article?id=info:doi/10.1371/journal.pone.0154164>

For example,

- Higher frequencies of skin and upper respiratory symptoms
- More hospital admissions per population for heart and nerve problems
- Decreased average birth weight and increase proportion of small for gestational age infants
- Higher incidence of heart defects at birth

# 5. Evidence-based Concerns

## Methane emissions, carbon footprint and climate change

Concerns about high levels and underestimated potency of fugitive methane emissions during drilling, production and transportation adding to, not protecting against, climate change and its health consequences

– acknowledging the importance of the 20 year climate forcing impact (80 times higher than CO<sub>2</sub>) as opposed to the 100 year timeframe

Intergovernmental Panel on Climate Change. Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge Univ. Press; 2013.



# Slide from presentation by Howarth, Ithaca NY

Climatic Change  
DOI 10.1007/s10584-011-0061-5

LETTER

## Methane and the greenhouse-gas footprint of natural gas from shale formations

A letter

Robert W. Howarth · Renee Santoro · Anthony Ingraffea

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**Abstract** We evaluate the greenhouse gas footprint of natural gas obtained by high-volume hydraulic fracturing from shale formations, focusing on methane emissions. Natural gas is composed largely of methane, and 3.6% to 7.9% of the methane from shale-gas production escapes to the atmosphere in venting and leaks over the lifetime of a well. These methane emissions are at least 30% more than and perhaps more than twice as great as those from conventional gas. The higher emissions from shale gas occur at the time wells are hydraulically fractured—as methane escapes from flow-back return fluids—and during drill out following the fracturing. Methane is a powerful greenhouse gas, with a global warming potential that is far greater than that of carbon dioxide, particularly over the time horizon of the first few decades following emission. Methane contributes substantially to the greenhouse gas footprint of shale gas on shorter time scales, dominating it on a 20-year time horizon. The footprint for shale gas is greater than that for conventional gas or oil when viewed on any time horizon, but particularly so over 20 years. Compared to coal, the footprint of shale gas is at least 20% greater and perhaps more than twice as great on the 20-year horizon and is comparable when compared over 100 years.

**Keywords** Methane · Greenhouse gases · Global warming · Natural gas · Shale gas · Fracture fuel

## Climatic Change

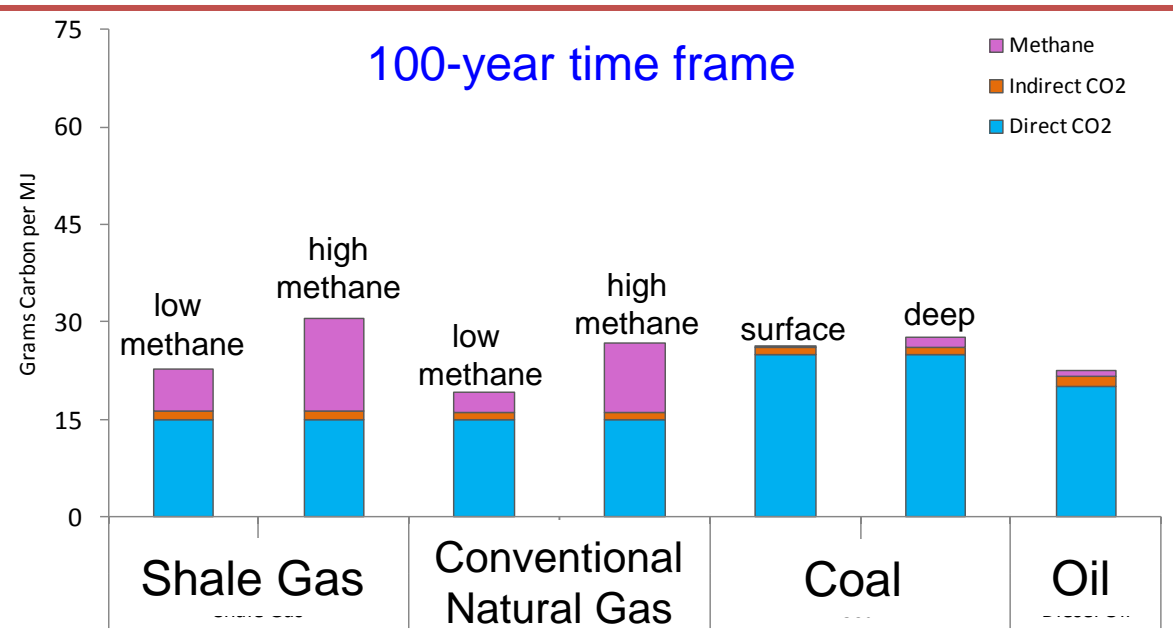
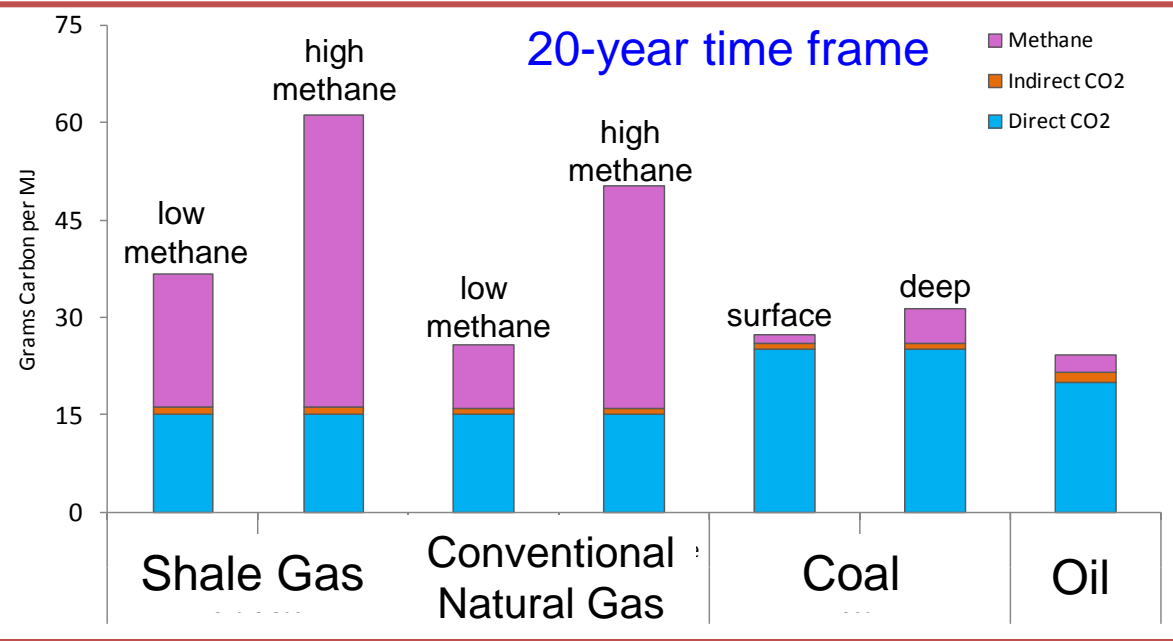
An Interdisciplinary, International Journal Devoted to the Description, Causes and Implications of Climatic Change

Co-Editors MICHAEL OPPENHEIMER  
GARY YORRE

14853, USA

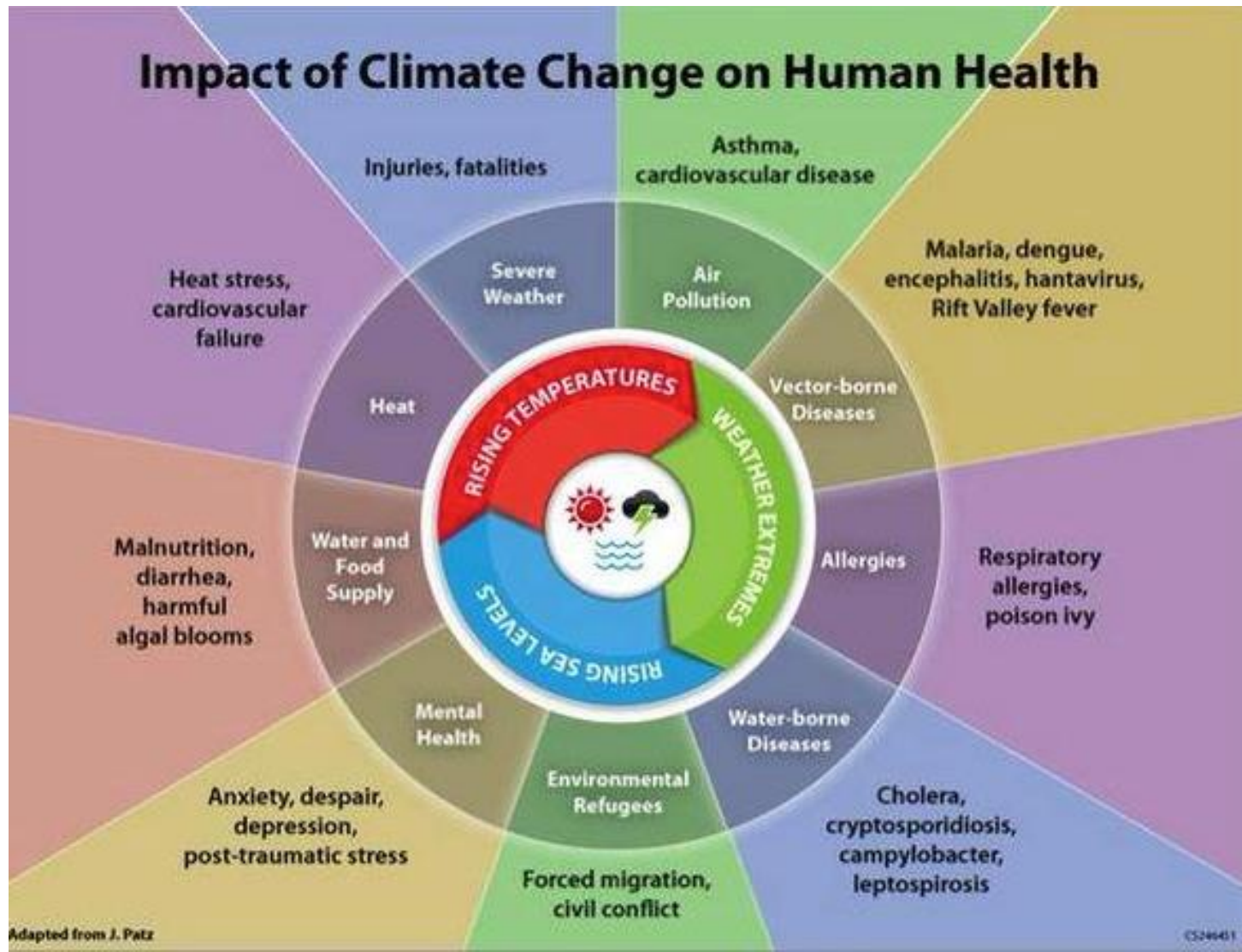
853, USA

Springer



# Responding to climate change is the biggest health challenge of our time.

Lancet Commission on Health and Climate 2015 (2015). Health and climate change. <http://climatehealthcommission.org/the-report/>



# A CLIMATE OF SUFFERING:

the real costs of living with inaction on climate change

Mental health and community wellbeing  
in the wake of extreme weather



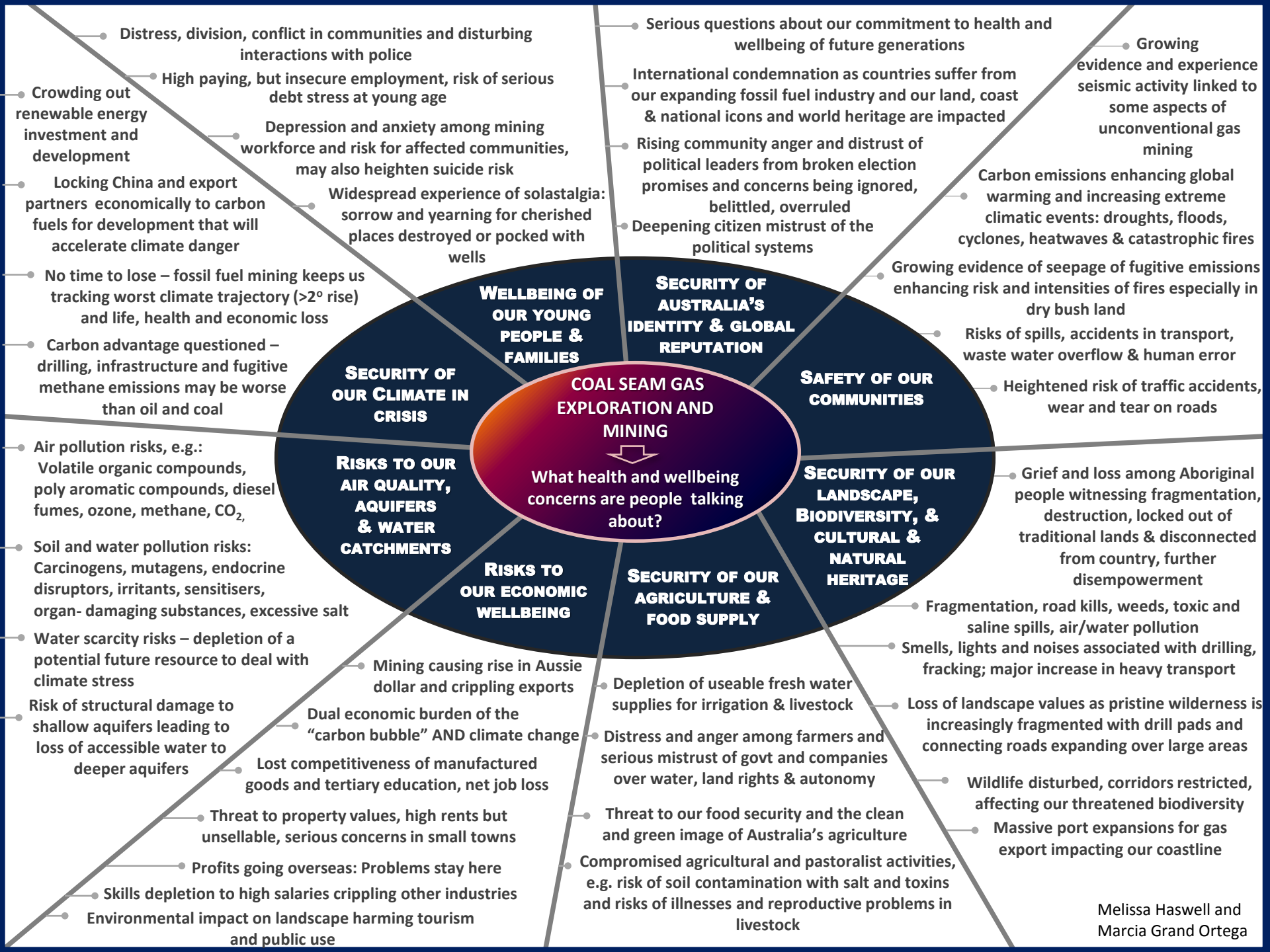
Compounding stress  
and impacts on mental  
health, especially on  
farmers

Mental health  
vulnerability is a major  
health concern.

## 6. Evidence-based Concerns

Questions about the ability of regulation to eliminate these potential risks and harms

Uncertainty about the effectiveness and feasibility of regulations to provide comprehensive, long term protection against the full range of health risks and concerns and cumulative environmental impacts.



Many health organisations have expressed serious concern about the health uncertainties linked to unconventional gas **and call for precautionary principle**  
– i.e. **‘if in doubt, turn it off’**  
**until safety is proven.** These include:

In Australia:

- Doctors for the Environment Australia
- Australian Medical Association (CSG)
- Public Health Association of Australia
- Climate and Health Alliance (which itself has numerous health organisations members)

In the United States:

- American Academy of Paediatrics
- American Public Health Association
- Physicians for Social Responsibility
- Many other health and medical groups....



**TACKLING CLIMATE  
CHANGE COULD  
BE THE GREATEST  
GLOBAL HEALTH  
OPPORTUNITY OF  
THE 21ST CENTURY**

**The Lancet, June 2015**

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