Reg Environ Change (2014) 14:699–712
DOI 10.1007/s10113-013-0529-0

ORIGINAL ARTICLE

# Subregional differences in Australian climate risk perceptions: coastal versus agricultural areas of the Hunter Valley, NSW

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Received: 5 October 2012 / Accepted: 30 August 2013 / Published online: 17 September 2013


**Abstract** 'Environmental cognitive stress' a hybrid model combining environmental stress and cognitive determinants of pro-environmental behavior is explored among Australians living in contrasting 'micro' climates in the same river catchment system. Peoples' climate risk perceptions are mediated by their connections to local environment, observations of environmental change and personal weather experiences. A longitudinal study randomly sampled 1,162 Hunter Valley coastal and rural residents in New South Wales. Telephone interviewers (2008) recruited lakeside homeowners 'at risk' of sea level rise, nearby 'control' residents and a comparable farming area group. Follow-up interviews (2011) located 81.5 % of the original sample. Fifty-six items based on the model asked about climate change observations, concerns, impacts and actions. Statistically significant rural–suburban and time differences were found. The rural sample was attuned to conditions affecting agricultural productivity: They worried about drought and heat, saw trees dying and changes to seasons and natural rhythms. They anticipate the impact of water scarcity, conserve water and value protecting plants and animals. Compared to higher elevation residents, lake dwellers observed marine life loss, worry about sea level rise and predict the decline of property values. Across time, all groups' perceptions of warming indicators declined. Concerns and impacts were high and generally stayed high, as did actions related to energy use. No differences emerged in beliefs about climate warming. Climate change observations, along with concerns and actions, have important implications for the environmental cognitive stress model. Overall, dynamic changes in residents' understandings are related to a changing policy environment, the vicissitudes of climate debates and weather experiences, including extreme swings from inundation to drought.

**Keywords** Climate change · Risk perceptions · Subregional differences · Urban vs rural · Australia · Longitudinal survey

**Electronic supplementary material** The online version of this article (doi:10.1007/s10113-013-0529-0) contains supplementary material, which is available to authorized users.

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## Introduction

Climate science reports timed for the 2012 Doha round of global climate negotiations warned that carbon emissions were tracking at the extreme end of predictions (Peters et al. 2012). Without strong mitigation, 4–6 °C rises in temperature would occur by the end of the century. In a 4 °C warmer world, the planet would be almost unrecognizable: 'unprecedented heat waves, severe drought and major floods in many regions, with serious impacts on human systems, ecosystems and associated services' (World Bank 2012 p. xiii). Dire predictions from credible science organizations have increased since the 1990 IPPC. Yet, since then, global greenhouse gas emissions have increased 58 % (Peters et al. 2012).

Climate change information is ubiquitous in daily life. However, the public's attention, interpretation, comprehension and action in reply to global warming messages are governed by complex perceptual processes, not fully explained (Weber 2010; Reser et al. 2012a). This knowledge gap hinders the ability to mobilize the public toward immediate action to mitigate the long-term effects of planetary warming. Psychologists point out that perceptions of climate threat may be muted because global warming is remote in time and space; clouded in uncertainty; not directly experienced; may be of concern analytically, but not emotionally; readily replaced in our attention by immediate priorities; and is considered beyond one's personal power to control (APA 2009; Wolf and Moser 2011; Weber 2010). Dire predictions of runaway climate change potentially engender intra-psychic 'terror management' strategies to reduce anxiety, through denial of threat and retreat toward conservatism (Dickinson 2009; Connor 2010a, b). Furthermore, mitigation measures are expensive and require radical solutions (e.g., a 'low carbon' economy) for uncertain future gains. Scientific messages are treated skeptically when filtered through cultural 'meta-cognitions' about the weather, political ideology and religious precepts about the rightful place of humans on earth. Climate science is under attack by vested interests profiting politically from the fear of change or fighting to retain the privileged position of fossil fuel and carbon intensive industries (Connor 2010b).

This phenomenon demands engagement of multiple social and cognitive perspectives. Environmental psychology contributes a synthesis of cogent models, as no one psychological theory will explain the variation in human experience of climate change and action (Wolf and Moser 2011; Reser et al. 2012a). Toward this end, the APA Taskforce on climate change presented a framework integrating psychological models of stress and coping, environmental stress and adaptation processes (APA 2009; Reser and Swim 2011). Reser et al. (2012a) point out the challenges of integrating these diverse approaches, but doing so offers the best wisdom for designing public interventions, along with elements of proactive coping (Folkman 2011).

## Environmental threat appraisal, cognition and coping

In line with Reser et al. (2012a), we postulate that an environmental stress approach (Baum and Fleming 1993; Evans and Stecker 2004), combined with cognitive stress theory of pro-environmental behavior (Homburg and Stolberg 2006), helps explain people's responses to global warming and identifies psychosocial drivers of climate action (APA 2009) (See Fig. 1). The environmental/cognitive stress model posits that climate adaptation begins with *direct or indirect experiences of global warming* (e.g.,

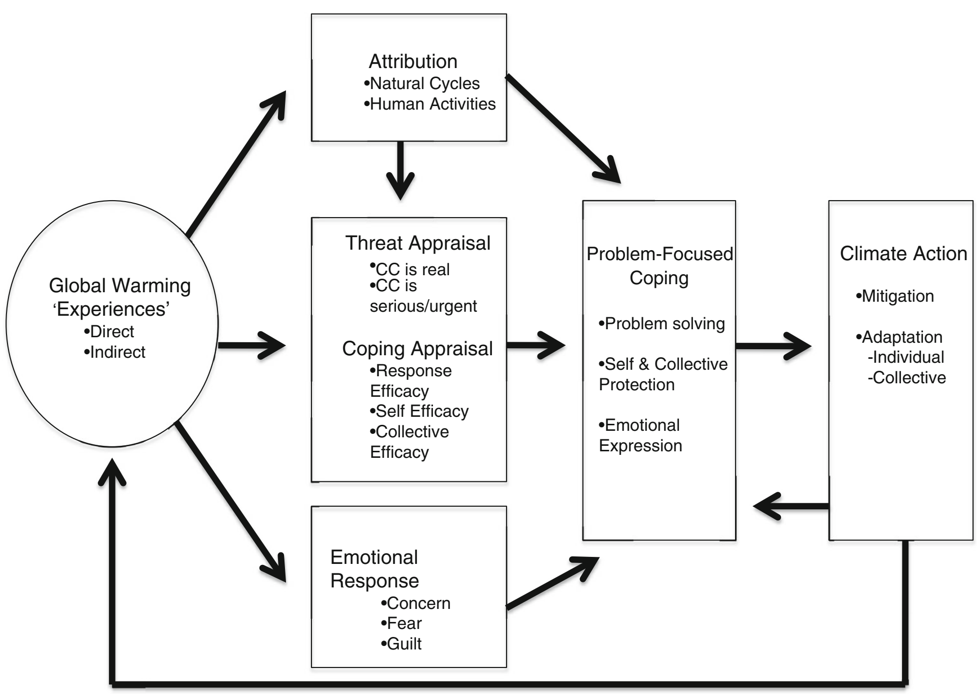


**Fig. 1** Environmental cognitive stress model of global warming

local heat wave or news about a Pacific island facing inundation). *Threat appraisal* is activated: 'Will the warming events exceed available resources, harming me, my family, the community and other natural systems?' 'Is it urgent?' Influencing appraisal is the *attribution* of whether this is simply a 'natural cycle' or caused by human activities and needs addressing (Connor and Higginbotham 2013).

The second appraisal stage is *coping appraisal*; evaluating different responses to warming: 'Could these responses prevent or reduce harmful climate change (response efficacy)?' 'Do I have the ability to do the necessary behavior (self-efficacy)?' Or 'Can we as a group (wider network/government/science) undertake what is needed (collective efficacy)?' In parallel with the threat and coping appraisal is the *emotional response* itself to climate change experiences—'risk as feeling' (Bohm 2003; Slovic 2010). Emotional processing of information about global warming is particularly important for arousing motivation to act (concern, fear, and guilt). The absence of direct experience of events is a barrier to affective engagement with this issue (Weber 2010). Next, appraisal and affective responses trigger *problem-focused coping*. Such coping, made up of problem-solving, expression of emotion, and (or collective) self-protection, prepares and regulates *climate action* itself—i.e., action at different levels to prevent further global warming (mitigation) or reduce its impact (adaptation) (See Roser-Renouf and Nisbet 2008). Figure 1 shows a feedback loop whereby success at taking climate action encourages further problem coping, such as consumer lifestyle change, and carbon policy formulation. However, global warming experienced as an uncontrollable, chronic environmental stressor may lead to a substantial decrement in motivation to take action (Evans and Stecker 2004).

Components of the 'environmental cognitive stress' model have received support in the literature. The APA Taskforce (2009) argues that characteristics of people and community (e.g., resilience and vulnerability), and the incident itself, act as moderators at each step in the coping process (APA 2009). Homburg and Stolberg's (2006) test of the cognitive stress theory supported the notion that appraisal of environmental stressors, such as global environmental problems, activates problem-focused coping, which in turn leads to pro-environmental behavior in the public and private spheres. They observed that collective efficacy determined coping and subsequent environmental protection. Other German studies found the stronger the respondents' emotions (anger and sadness) about environmental changes, the more likely they were to practice pro-environment behavior such as public transportation use and energy conservation (Homburg et al. 2007; Kals et al. 1999). Van Zomeren et al. (2008, 2010) show that when viewed as a collective problem, the emotional experience of global warming and perceived group efficacy to solve the problem make up distinct (dual) pathways to collective climate action (see also Grothmann and Patt 2005).

## Central role of fear, guilt and emotion

Psychological models explaining pro-environmental behavior have typically contained affect/emotion components, both in terms of the hazard itself or affect toward the behavior (Homburg and Stolberg 2006; Steg and Vlek 2009; Weber 2006). Ferguson and Branscombe (2010) performed a laboratory test of the role of collective guilt in mediating climate change mitigation behavior. When people believe that their group is responsible for harming the natural world and that the damage can be repaired, their feelings of collective guilt are likely to elicit behaviors to repair the harm done.

The emotion aroused by climate change provides a critical link between knowledge, attitudes and action (Wolf and Moser 2011; Weber 2006, 2010; Leiserowitz 2006; Slovic et al. 2004; Sundblad et al. 2007; Patchen 2010). Wolf's (2010) Canadian research found that 'ecologically minded' people are more engaged with climate change emotionally. Wolf and Moser (2011) found that people were more effectively engaged emotionally by positive messages. Fear appeals have been found to be counterproductive because they are perceived as manipulative (O'Neill and Nicholson-Cole 2009). When people become fearful, they may react by denying that the threat is real or by avoiding thoughts about the subject. Strong guilt arousal may lead people to react with resentment of the communicator, denial of responsibility, and negative behavior (Bohm 2003; Homburg et al. 2007).

## Direct experience of threat or disaster

Direct experience of extreme weather events appears to shape threat appraisal. People become more concerned about climate change when there is some immediate evidence impacting their lives, such as unprecedented heat waves, flooding or coastal erosion (Bickerstaff et al. 2004). The degree of climate concern in 15 European countries varies as a function of the average local temperature in July, the hottest month in Europe (Lorenzoni and Pidgeon 2006). Nearly 60 % of a post-hurricane poll of Americans believed that climate change was adding to the severity of recent extreme weather such as Superstorm Sandy (Zogby 2012). However, personal experience alone may not be sufficient. Weber (2010) argues that experienced adverse consequences need to be seen as causally connected to the phenomenon under consideration, while Whitmarsh (2008) found that UK flood victims' experiences must be paired with personal pro-environmental values to motivate action.

## Study aims

Wolf and Moser (2011) urge in-depth studies to understand how climate perceptions differ by socio-demographic groups and learning contexts. Which groups make changes in their lives toward (or against) mitigation and adaptation responses? The present study explored public perceptions of climate change in-depth using the 'environmental cognitive stress model.' It sought to understand how specific risk perceptions, appraisals, affect and actions vary within subregional populations, between subregions and across time; data that will inform a fine-grained appraisal of the model.

Specifically, this research aimed to:

1. Describe direct observations of local climate change (Global Warming Experiences); feelings of concern about such changes (Emotional Response); beliefs about likelihood of impacts (Threat Appraisal); and deliberate action in response to climate experiences (Climate Action);
2. Examine differences in climate risk perceptions across coastal urban and rural farming populations, characterized by different climate risk exposures (sea rise vs drought) and economic conditions;
3. Analyze climate risk perceptions across time to determine how they change, who has changed and how changes are linked to external dynamics such as government policy, political debates and extreme or unusual weather.

## Australian climate change context

Climate change effects play out differentially across regional and local areas. In Australia, annual average warming by 2030 (above 1990 temperatures) is estimated around 1.0 °C (0.7–0.9 °C in coastal areas and 1–1.2 °C in inland (Cleugh et al. 2011)). An increase in fire-weather risk is likely with warmer and drier conditions, along with increases in heat-related deaths. Local governments in the East Coast region of the Hunter Valley have undertaken their own modeling showing variability within local areas. The Hunter coastal 'climate zone' expects increased extreme storm events, while the Hunter's central and western zones will experience more days of extreme heat (Blackmore and Goodwin 2009). Local authorities have undertaken risk analysis based on such modeling to determine measures to protect assets, plan long-term mitigation and adaptation strategies and make changes to planning practices within their jurisdictions (e.g., Giles and Stevens 2011). Surveys to gauge public perceptions of climate change risk locally vary across rural and urban locations.

### Australian surveys of climate change risk perceptions

Australian national surveys indicate that a majority accepts that climate change is occurring and is concerned about its effects (The Climate Institute 2010; Leviston and Walker 2010; Reser et al. 2012b). In mid-2011, CSIRO surveyed 5030 participants online and found that 77 % of respondents agree climate change is happening, but are evenly split on whether it is anthropogenic in origin (Leviston and Walker 2011: 6–8). However, when given a choice of attributing this change to *both* human and natural causes, the perception of human involvement rises to nearly 80 % (Reser et al. 2012b), demonstrating the importance of how climate questions are framed (Bruine de Bruin 2011; Krosnick 2010). Griffith University's online survey ($N = 3{,}096$) also found high levels of acceptance (74 %) that the world's climate is changing; furthermore, 78 % saw it as a serious problem if nothing is done to reduce it (Reser et al. 2012b). Beliefs about climate change have been strongly linked to political preferences, policy, age, education and gender (The Climate Institute 2010; Reser et al. 2012b). However, no clear relationships have emerged between beliefs and location and/or region.

WIDCORP (2009) took a localized approach in studying the attitudes of 1,503 Victorian farmers toward climate change across seven agricultural sectors and 12 regions. In contrast to national surveys, responses were highly varied according to industry and regional concerns. Buys et al. (2012) interviewed a small number of rural residents in Tasmania and the NSW/Victoria border. In line with previous research among farmers, their interviews found a clear division about the existence of climate change vs weather variability, and whether it merited immediate (proactive) action or a 'wait and see' (reactive) approach. Evans et al. (2009) explored 411 rural Western Australian's attitudes toward climate change science and the role of government, contrasting four regions. Like the WIDCORP (2009) report, attitudes and opinions toward climate change varied considerably from the national surveys and showed regional variability. Only 32 % of farmers surveyed accepted that climate change was happening and 26 % considered it a result of human activity. Farmers held cynical views about government motives and the use of climate change science for personal and political agendas (Evans et al. 2009: 3–4).

The variation in these localized studies compared to the findings of national surveys is more than an artifact of method or question framing (Krosnick 2010). It suggests the importance of investigating regional understandings as well as responses to public education and policy initiatives relating to climate change. Hence, this study assessed subregional differences within the Hunter region of NSW and examined local residents' changes across time, relating those changes to wider social, political and environmental influences.

## The study area

This research is part of a larger investigation using a region-wide view to analyze how knowledge of climate change is understood and acted upon by a range of contrasting local communities and groups in the Hunter Valley. This region is loosely defined by the catchment of the Hunter River, with a population of 630,000 concentrated in urban and suburban coastal areas and Lake Macquarie. The project focused on two geographic areas within the region. The first is the predominantly rural Upper Hunter Local Government Area (LGA) (population 14,000; 8,000 $km^2$). In the Upper Hunter LGA, grazing, dairy farming and horse breeding compete with significant industrialization that has developed in adjacent Muswellbrook and Singleton LGAs, where open-cut coal mines, coal seam gas drilling and coal-fired power generation dominate. Apart from domestic consumption, the mines produced 122 megatonnes of coal for export in the financial year 2011–2012 (Newcastle Port Corporation 2012), shipped from the Port of Newcastle, the world's largest black coal exporting port.

The second area is Lake Macquarie (LGA) (population 200,000; 757 $km^2$), where suburban communities border the coast and shoreline of Australia's largest saltwater lake (112 $km^2$). Lake Macquarie LGA has the largest number of residential properties at risk from sea level rise and storm inundation in NSW (Department of Climate Change 2009). An estimated 7,800 residences and buildings on land below 3.0 meters AHD are likely to be affected by lake flooding with a projected 0.9 meter sea level rise by 2100 (Giles and Stevens 2011). Lake Macquarie Council has had a politically independent, 'environmentalist' mayor and takes a proactive approach to CO2 reduction and adaptation to global warming impacts.

These two Hunter study areas were chosen because of their contrasting forms of exposure to environmental change. Lake Macquarie's coastal 'climate zone' can expect sea level rise, increased extreme storm events ('East Coast lows') and consequent inundations, while the Upper Hunter's central and western climate zones will experience increased frequency of extreme heat days (Blackmore and Goodwin 2009). Demographically, Lake Macquarie and the Upper Hunter are comparable in terms of age (median = 41 vs 39 years) and affluence ($1,117 vs $1,071 weekly household income, respectively). They are similar in proportion of managers, professionals and trades workers; rural production dominates the economy in the Upper Hunter, while Lake Macquarie residents engage more widely in urban economic pursuits, such as the service and information sectors (Australian Bureau of Statistics 2006, 2011). Both areas have a history of opposing expansion of the coal mining industry, which threatens rural production enterprises in the Upper Hunter and environmental amenity/population health in the Lake Macquarie locale (see Connor et al. 2008, 2009).

## Method

A longitudinal study compared a random sample of 1162 Hunter Valley coastal and rural residents to assess regional and time differences in climate risk perception and adaptation variables suggested by the environmental cognitive stress model. Telephone interviews targeted people over 18 years of age who are involved in making decisions in their households. The baseline survey was conducted November–December 2008 (early summer) with equal numbers of coast and lakeside dwelling 'at risk' Lake Macquarie residents [LM-R; n = 395], Lake Macquarie 'control' residents [LM-C; n = 382] living away from the coast/lake and Upper Hunter rural residents [UH; n = 385]. The follow-up survey was administered February–April 2011 (late summer) and sought to telephone all of the initial respondents (see below).

### Questionnaire

Interviewees were asked 56 questions based on the environmental cognitive stress model, framed in terms of their local area (See Appendix 1, Electronic Supplement). *Global Warming Experiences* included observations of weather disasters (five items; less or more frequent, remained the same) and changes in local biodiversity and seasons (seven items; yes or no). *Emotional Response* comprised level of concern about these global warming experiences (12 items; very, somewhat or not concerned). *Threat Appraisal* encompassed likelihood of adverse climate impacts (13 items; unlikely, likely, neither) as well as beliefs that climate change is real (three items; disagree, agree, neither). *Climate Action* mapped a range of theoretically important behavior domains, including mitigation, adaptation, intentional, home energy conservation and collective action (eight items; will not do, might do, planning to do, already doing). *Climate Science* comprised beliefs about planetary warming (three items; disagree, agree, neither). The survey instrument format was based on our previous work on environmental distress in this region (Connor et al. 2004; Higginbotham et al. 2006).

Statistical tests

The Pearson Chi-square test was used to determine whether there were area differences (LM-C vs LM-R vs UH) in response to each of the 65 questions. Alpha was set at $p < .01$ because of the large number of tests and, given the large sample size, the desire to identify only psychologically meaningful differences. A result reaching $p < .01$ indicates that the responses are different across the three areas (i.e., at least one of the areas is different from the others).

The McNemar test for differences between paired proportions was applied to determine whether individuals' responses changed significantly between the baseline and follow-up periods. Questionnaire items included two, three or four response categories. The McNemar test indicated whether the proportion of respondents who changed in one direction (from baseline to follow-up) was greater than the proportion changing in the other direction. Again, alpha was set at $p < .01$.

As explained in Figs. 2, 3, 4, 5, 6, the letter B beneath a specific item indicates one or more area difference at baseline was statistically significant ($p < .01$). The letter F indicates one or more significant area differences at follow-up ($p < .01$). Similarly, the letter T shows a significant time difference between baseline and follow-up for one or more areas ($p < .01$). (See Appendix 2, Electronic Supplement for full explanation of each statistical result).

## Results

Demographic characteristics

Demographically, residents were long-term home owners (median 27 years), 60 % women and older (mean 55 years). Follow-up interviews in 2011 located 947 of the original sample (81.5 %). Our sample slightly over-represented professionals and under-represented laborers; a greater proportion owned or were buying their homes, compared to census data. Slightly more UH residents (22 %) were lost to follow-up compared with LM-R (18 %) and LM-C (14.4 %). Demographically, there was little distortion in the profile of those followed-up compared with the baseline respondents. The same proportion of men (39.7 %) and women (60.3 %) responded; similarly, education and work status were comparable. Age distribution was as expected given the 2-year time elapse. However, the household decision-makers' age profile shows a greater proportion in the 55 and older age brackets compared with census data for their LGA (e.g., LM respondents > 65 years = 33 vs 17 % in LM census).

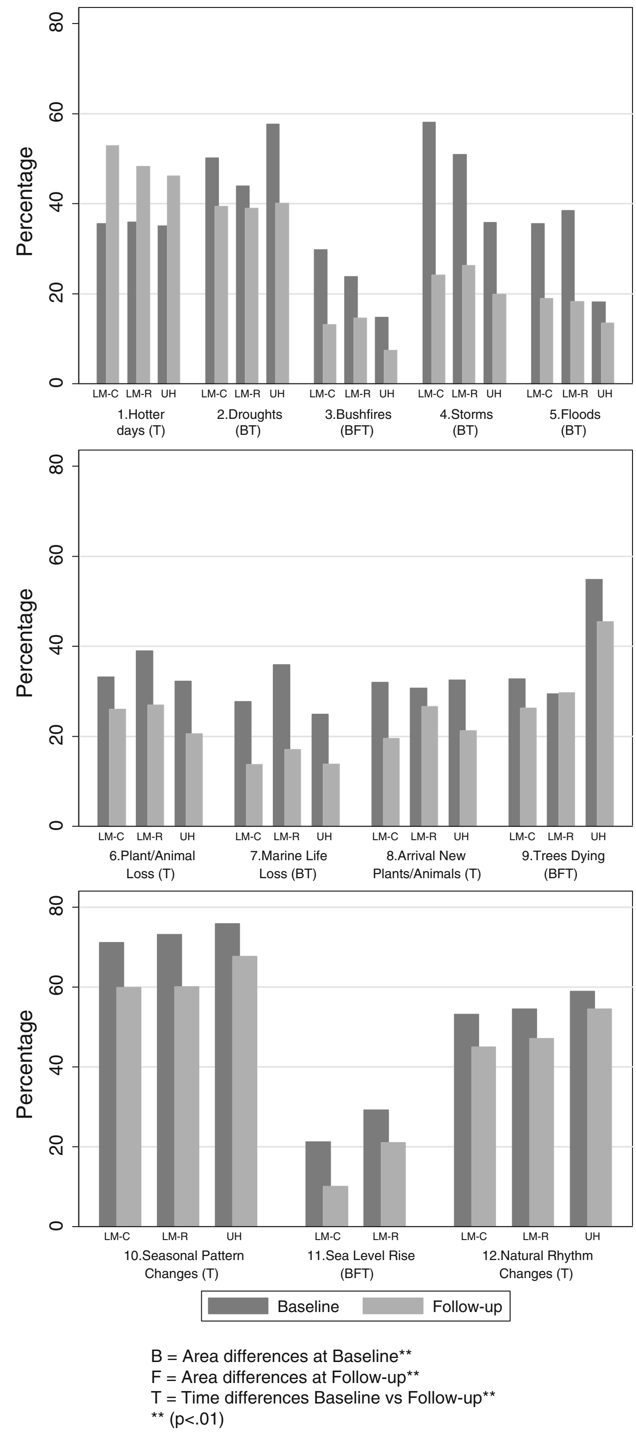


**Fig. 2** Percentage of residents observing climate change and natural events by area and time

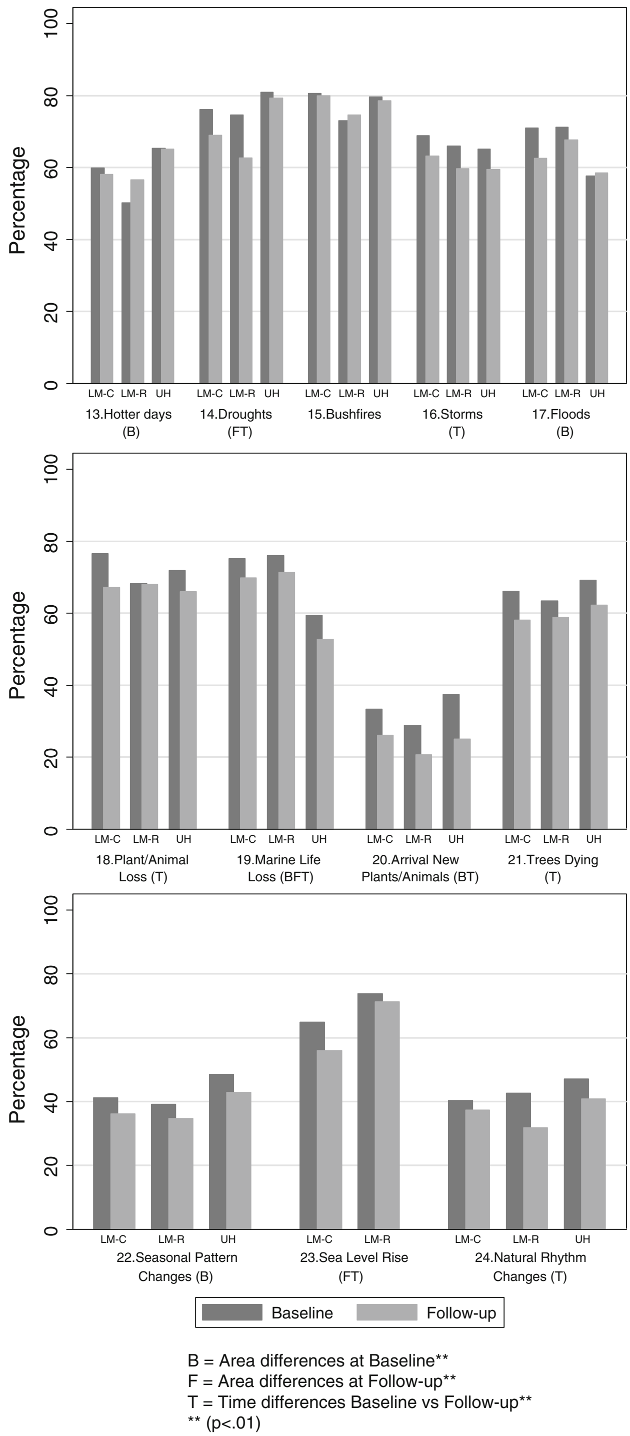


**Fig. 3** Percentage of residents 'very concerned' about climate change effects by area and time

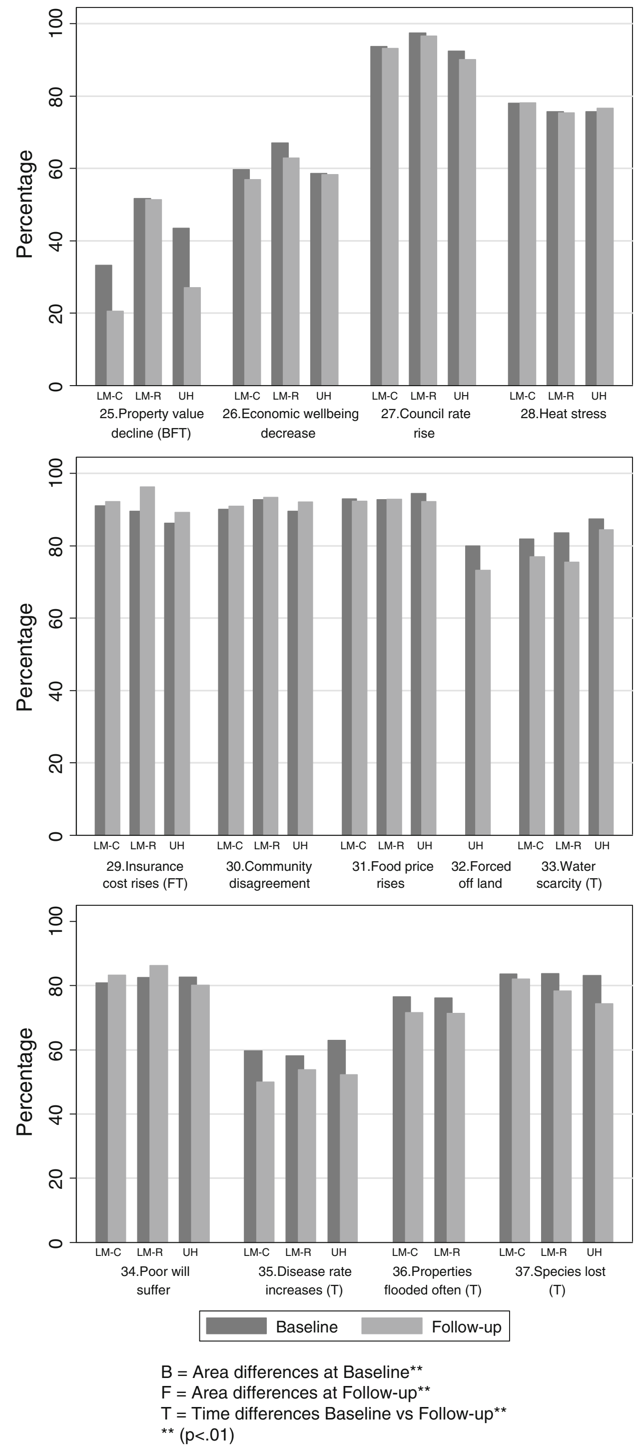


**Fig. 4** Percentage of residents who believe climate change impacts are 'likely' by area and time

## Climate change weather indicators and natural events

At baseline in 2008, 30–60 % of respondents observed a higher frequency of climate change weather indicators like heat and drought (See Fig. 2). Upper Hunter residents saw significantly more prolonged dry spells but lower levels of intense fires, storms and flash flooding than coastal people. At follow-up in 2011, the only area difference was bushfires, while four weather hazards dropped significantly (prolonged drought, high intensity bush fires, severe storms) and flash flooding halved in Lake Macquarie. Only observations of hotter days increased; half of all

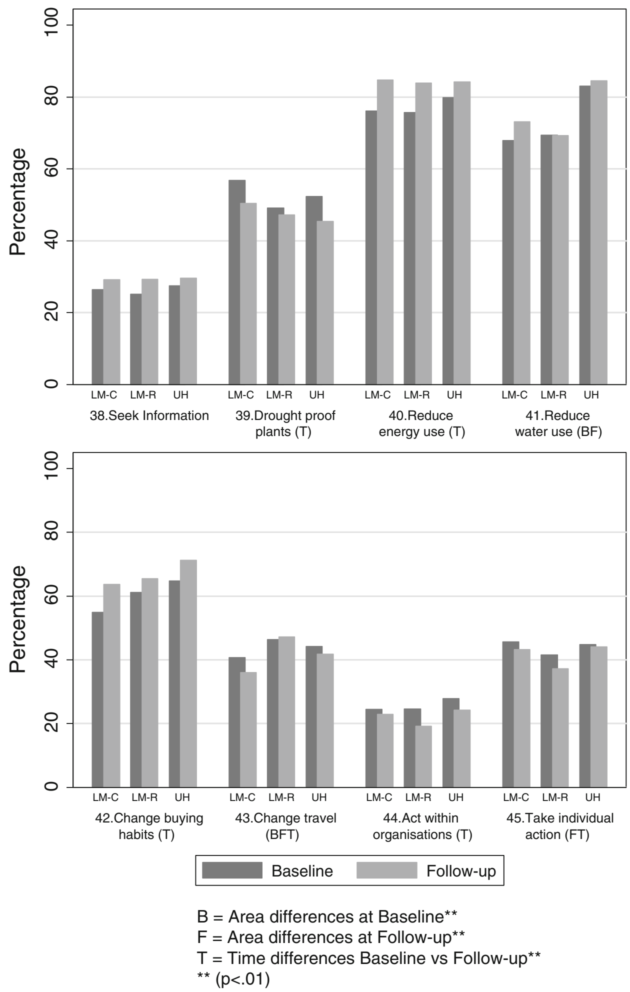


**Fig. 5** Percentage of residents 'already doing' actions to reduce climate change by area and time

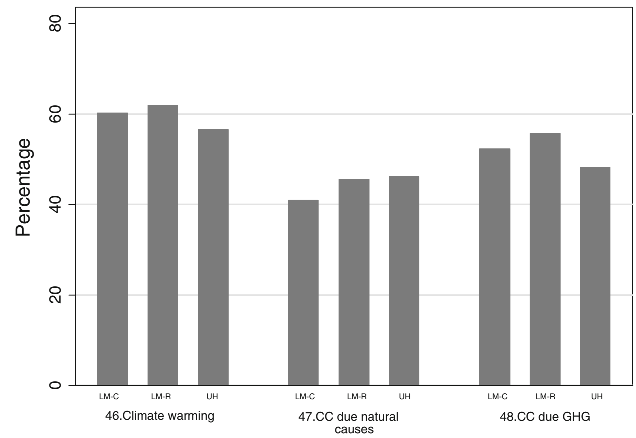


**Fig. 6** Percentage of residents 'agreeing' the world's climate is warming and its causes by area

respondents reported more hotter days. All changes are statistically significant.

Figure 1 shows that 30–70 % observed the seven climate-related natural events at baseline, like loss of native plants and animals, with three significant area differences. The LM-R group reported more loss of fish/marine life and sea level rise; UH residents saw more mature trees dying. These area differences persisted at follow-up. However, all 'natural event' sightings significantly declined, particularly loss of plants, animals and marine life. UH residents still saw considerable tree deaths (45 %) and changes to nature's rhythm (55 %), while a majority in all areas saw changing seasonal patterns (60–68 %). Significantly fewer Lake Macquarie residents reported sea level rise.

## Concerns about effects of climate change

Across most of the 12 climate change indicators, 60–70 % of interviewees at both survey periods would be 'very concerned' if these events occurred over the next 20 years. Figure 3 shows significantly more farmland residents at baseline felt intense concern about hotter days, arrival of new plants/animals and changing seasonal patterns, while LM residents were concerned about marine life loss and flash floods. Three area differences emerged at follow-up: Farmland residents retained concern about drought, but not marine life; those closest to the lake (LM-R) were more concerned about sea level rise.

Eight of the 12 concerns diminished at follow-up. The exceptions were hotter days, bushfires, floods and season changes. Nonetheless, most indicators remained at 60 % or higher 'very concerned.' Of least concern were items addressing rhythms of nature and arrival of new plants/animals. Overall, UH residents expressed more concern about events affecting agricultural productivity: heat, drought, changing seasonal patterns. LM-R residents remained at >70 % 'very concerned' about sea level rise, but not their LM-C neighbors.

## Impacts of climate change effects

Apart from property devaluation, a strong majority (60–90 %) believed that climate change impacts were likely (Fig. 4). Follow-up endorsement remained high, but significant declines were seen for water scarcity, disease rates, floods and species loss impacts.

About 60 % felt that their household economic well-being would decrease. While UH and LM-C felt property devaluation less likely, LM Risk residents retained 50 % fear of this impact. Not listed are items about rises in insurance, local government rates and food prices (+90 % likelihood). Nearly 80 % of rural residents feared climate change would force people off the land.

### Climate action

Climate action showed a complex pattern, across items, regions and time (Fig. 5). Conservation actions (reduce energy/water use) were high initially and improved (up to 65–85 %), with UH higher in water reductions. Three personal efforts had moderate support (40–50 %)—take individual action, drought proof plants and change travel habits. Seek information about climate change slightly rose (30 %). In contrast, five actions (not shown) were highly *unpopular* across all sites and fell even further at follow-up: changing jobs (2.5 %); modifying ones' house (25 %); moving to avoid sea rises (2 %); and take part in climate action groups or protests (4–7 %).

### Climate science beliefs

Three climate science items added in 2011 found that 60 % of respondents agreed, 'The world's climate is getting warmer'; 44 % felt 'any global warming' was due to 'natural causes'; while 52 % agreed, 'Human production of greenhouse gases is a leading cause of climate change.' About a quarter of people dismiss the idea of global warming and any human responsibility for it if it does exist. Interestingly, of those 44 % selecting natural causes, 37 % of that group also saw human produced greenhouse gases as a contributing cause. Similarly, of the 52 % selecting anthropogenic sources, 31 % of that group ascribed some role to 'natural causes.'

## Discussion

Overall, these longitudinal data suggest a marked decline in observations of climate change indicators (except hotter days), while concerns and expectations of future impacts remained elevated. Several climate actions under one's own control are strong, but activism is rare. Consistencies across the farming and suburban lake areas overshadow any differences that emerge. Self-selectivity of follow-up respondents with extreme views was not evident in the findings and unlikely with the 81 % follow-up (cf Leviston and Walker 2011).

### Decline in climate change indicators

Long-term Hunter residents noticed changes over time in climate-related natural events in their area. Kempton et al. (1995) found that people claim to have personally observed the effects of global warming and suggest people have a historical propensity to perceive weather change, whether or not it is occurring, and to attribute it to human activities that occur in the atmosphere and are regarded as unnatural or immoral (e.g., space shots, pollution).

The effect of local weather conditions prior to our two surveys is unmistakable. At baseline, the Hunter region had just emerged from a severe seven-year drought that had wrought damaging consequences, especially for farmers (Polain et al. 2011). A 1/100 years East Coast cyclone had severely damaged the Lower Hunter with torrential rain, flooding, electricity cuts and loss of life. Respondents' perceptions of more frequent droughts and mature trees dying in the UH and storms/floods in LM are clearly tied to these events.

Prior to the follow-up interviews, unprecedented extreme weather events struck Eastern Australia, with a highly destructive 'inland tsunami' in Queensland, followed by severe tropical Cyclone Yassi and an extreme heat wave in the Hunter reaching remote desertlike temperatures (43 °C). Respondents' perceptions of hotter days rose, with all other indicators dropping. Our informants did not generalize the ongoing flood trauma in Queensland to local area observations. This bears out Whitmarsh et al's (2011) observation that one difficulty with communicating climate change risk to the general public is that it is embedded in natural and familiar seasonal patterns. The direct 'lived experience' of changing weather and seasonal patterns, such as familiar droughts and floods, may not be attributed to climate change.

While some observations are influenced by recent local weather events, others are stable and tied to long-term observations and beliefs about nature. Climate scientists suggest that lay people cannot detect climate change signals amid the background noise of natural fluctuations. Yet, many think they do perceive such changes and do so differentially across indicators and across time. Reser et al. (2012b: 172) concur: 'How else would most individuals be able to make psychological and adaptive sense out of the complexity of climate change, but through such analogical thinking and personal and local experience?'

Exploration of these perceptions should be integral to studies of risk and adaptation. They merit prominence in developing the environmental cognitive stress model, given the role of hazard observation in motivating action (e.g., Folkman 2011; Reser et al. 2012a). NASA climate scientists support this conclusion, noting that extreme weather events, such as 2011 droughts in Texas and Oklahoma, the Russian heat wave in 2010 and the European heat wave in 2003, are the consequences of global warming because 'their likelihood in the absence of global warming was exceedingly small' (Hansen et al. 2012).

### Concerns

Global warming emotional reactions were assessed by how concerned residents would be if indicators occurred over the next 20 years. Clearly, respondents felt very concerned about extreme weather events becoming more frequent. Concern fell at follow-up, but remained high (60–80 %) indicating ongoing significance and thus a key component of the theoretical model.

These findings contrast with other 2011 surveys showing significant reductions in respondents' concern about climate change since the peak in 2006. Hunter Valley Research Foundation (HVRF) survey found that 64 % of Hunter people agreed that climate change would have a direct impact on their lives in the next 20 years, compared to 80 % in 2006 (HVRF 2011). The Lowy Institute found that 36 % of Australians in 2011 agreed that 'global warming is a serious and pressing problem,' versus 68 % in 2006 (Lowy Institute for International Policy 2012). In the USA, 43 % agreed that 'the seriousness of global warming is generally exaggerated,' up from 30 % in 2006 (Jones 2011), but lower than 48 % in 2010. Similarly, the June 2012 Washington Post-Stanford University national poll showed 18 % identifying global warming as the 'single biggest environmental problem the world faces,' down from 33 % in 2007 (Washington Post 2012). Interestingly, polls in 2013 showed a bounce back in American opinions from the 2010 trough. Significantly greater proportions believed global warming is occurring, worry about it, believe it is underestimated and attribute it to human activities (Gallup 2013; Pew Research 2013).

This decline of concern in 2010–2011 may reflect the reprioritizing of 'worry' following the global financial crisis. Alternatively, it may indicate 'crisis fatigue' in respondents engaged with such a long-term phenomenon. However, Krosnick (2010) argues that some of the documented decline can be attributed to poor survey construction. For example, the Pew surveys frame warming by 'From what you've read and heard,' thus biasing answers toward current media coverage (Romm 2011; see also Brulle et al. 2012). Our items assessing concern are tied to specific hazards that people judge as threatening or not if they were to occur. This observation is borne out by the specificity of the high concern items in the different areas of the Hunter Valley. Drought and other indicators adversely affecting farmers are UH issues; sea level rise is a dominant concern for the LM-R respondents.

### Impacts

The perceived likelihood of climate change impacts (threat appraisal) remained constant and elevated across time. The most likely impacts affected household budgets: food, insurance and local government taxes. LM-R residents had their negative predictions justified. In late 2008, Lake Macquarie Council introduced a policy of putting a notation on property certificates in the Sea Level Rise zone of .9 meter by 2100, to indicate properties that are vulnerable to increased flood and rising lake levels (approximately 10,000 parcels) (Giles and Stevens 2011). This sparked mounting criticism from some homeowners and property developers claiming property values would decline. Residents living near the lake inundation risk zone anticipate greater impacts on economic well-being and council taxes.

Elevated risk perceptions reflect two processes documented in the literature. First, Australians in general are less prone than other citizens to viewing climate change as a distant threat. As a land of cyclical droughts, bushfires and floods, Australians are familiar with environmental hazards as immediate, proximal events. British more willingly agree that 'climate change will affect areas far away from here' (32 vs 8.5 % for Australians) (Reser et al. 2012b: 62). Second, those with past experiences of disasters are inclined to see current weather events as influenced by climate change. Reser et al. (2012b: 127) observed from their survey: 'Climate change appears to have particular salience, immediacy and meaning for respondents in terms of their local environment and their exposure to and experience with extreme weather events.'

### Climate action

Actions clustered around daily conservation and money saving routines under personal or household control. Patchen (2010: 51) postulates that 'willingness to act' increases as people see 'environmental problems to be more costly and "green" actions to be more beneficial.' Actions to change buying habits and reduce energy use (already the most frequent action) increased, the latter reflecting a widespread trend in Australia for declines in household electricity usage (West 2012). Electricity prices increased markedly in this period, so energy reduction has palpable economic benefits for households. Gardner and Stern (2009) demonstrate that households and individuals generate 21 % of total USA carbon emissions. A short list of low/no cost energy saving actions around the home can reduce energy use by up to 30 %. Drought-prone UH residents more often reported water conservation. The lack of a town water supply, the history of water shortage in rural areas and signs of drought reappearing may have influenced this behavior. Australian farmers, the backbone of the nation's economy for most of its settlement history, have attitudes about adaptation to landscape and weather formed through the perennial struggles with the extreme variability of the continent's climate (Sherratt et al. 2005).

There was increased resistance across time to undertaking more disruptive and expensive life changes, such as moving or modifying one's home and changing jobs. Those next to the lake were significantly more willing to consider or undertake home modification (43 % LM-R vs 30 % LM-C) and also more willing to contemplate moving away (32 % LM-R vs 14 % LM-C). Climate activism was unpopular; joining protest rallies and action groups (proactive coping) tend to be associated with a younger, urban demographic rather than this older suburban/rural sample.

In sum, this action profile reinforces Whitmarsh's (2009) notion of 'asymmetry of intentions and impacts' related to climate behavior. She found only 31 % of British surveyed explicitly act out of concern for climate change, although a vast majority regularly perform energy reduction and recycle, and many walk/cycle to work or use public transport. Reser et al. (2012b) found that age was positively correlated with daily conservation and money saving routines, practices that appealed to our older sample as well.

### Believers and sceptics

At baseline, we estimated about 20 % were skeptical of anthropogenic climate change, based on an open-ended question showing they held a 'natural cyclical change' viewpoint (Connor and Higginbotham 2013). With the follow-up survey, we asked this directly and found 25 % denying global warming or human involvement. This figure conforms to the CSIRO Baseline Survey 2011 (23 %), Newspoll 2010 (22 %) and Washington Post-Stanford 2012 (25 %). However, with just 60 % in the Hunter believing that the climate is warming, our residents are well below wider Australian (73–77 %) (Newspoll 2010; Griffith/Cardiff; CSIRO Baseline Survey 2011 (77 %)) and UK/USA polling (73–78 %) (Washington Post-Stanford 2012; Griffith/Cardiff 2010).

About 52 % of our residents endorsed anthropogenic causes for climate change. Such estimates are influenced by a framing 'effect' in which greater endorsement follows question formats that allow graded choices (e.g., partly, mainly, entirely human caused) as opposed to human vs natural variation choices (e.g., Leviston and Walker 2011). Our questions asked about human and natural influences separately, and the 52 % 'human-induced' result falls generally between the two formats (e.g., Ipsos 2010 graded choices 77 %; CSIRO Baseline Survey 2011 binary choice, 46 %). However, our finding that natural causes is endorsed by 44 % of Hunter homeowners is higher than most other surveys, ranging from 17.5 to 42 % (See Leviston et al. 2011; Washington Post-Stanford University Poll 2012).

Skeptical views on climate change have been well covered in mass media and supported by the federal government opposition (at that time), who appeared at anti-climate change rallies with 'celebrity sceptics' (Connor 2010b). Taylor (2009) notes that public debates about climate change influence how people make sense of climate change, particularly if the agenda is to create a sense of scientific uncertainty. Since 2010, the electorate has experienced intense debate about the necessity for a carbon tax introduced in July 2012, and its alleged negative financial consequences for individuals and households. This campaign of fear by opponents may have influenced the follow-up survey responses in a negative direction, raising concerns about the very climate change impacts that our survey indicates respondents are most sensitized to—household budgets (see Brulle et al. 2012).

## Conclusions

Australian national surveys show small differences in beliefs between urban and rural samples (Leviston and Walker 2010, 2011; Reser et al. 2012b). These similarities diminish when specific groups such as farmers are studied, who voice the lowest levels of belief (about 27 %) regarding anthropogenic warming (Donnelly et al. 2009; Evans et al. 2009). The significance of the subregional comparison analyzed in this article is the ability to pinpoint specific perceptions that vary between rural and suburban locations, between those facing flood risk and their higher elevation neighbors, and to observe whether these change with time. The rural sample was attuned to landscape conditions that mattered to agricultural productivity: They observe and feel concerned about drought and heat, see trees dying and worrying changes to seasons and natural rhythms. But rural people observed less climate change impacts in the way of storms, floods and bushfires and did not think species would be lost. They anticipated the impact of water scarcity and conserve water. Compared to nearby residents, those living near the lake observed marine life loss, had greater worry about sea level rise and predicted the decline of property values. In this context, they wanted government to fund protective flood barriers around the lake. Both suburban groups observed more storm activity than the rural sample.

Such differences stand in contrast to the weight of commonalities found. All areas declined in perceptions of global warming indicators, apart from hotter days. Concerns were uniformly high and generally stayed that way; perceived impacts of global warming failed to decline much, indeed several increased (e.g., insurance costs), as did actions (e.g., reduce energy use). Similarly, no regional differences emerged in beliefs about warming or its causes.

In-depth analysis of items that make up the components of environmental cognitive stress suggests some perceptions are sensitive to place and time. The greatest variability was in climate change observations; each item changed with time and several discriminated between areas as well (e.g., bushfires, trees dying). Concern/threat and climate action components performed moderately well (especially 'marine life loss,' and 'change in travel habits'). In contrast, impacts were uniformly seen as likely and few impacts declined (cf property devaluation). This study did not include the coping/resource appraisal component, but indicates that the other components have much promise when the environmental cognitive stress model is tested more formally using structural equation modeling and similar techniques.

Residents' perceptions and understandings are evolving dynamically across time, as they monitor a changing policy environment, are exposed to the vicissitudes of climate change debates and experience highly variable weather patterns. National surveys often obscure respondents' different exposures to their unique 'micro' climate zones and the diverse ecosystems to which they constantly must adapt. Long-term residents are agents within such ecosystems. Their climate change concerns and responses are mediated by their connections to local environment, their observations of environmental change and the personal experience of weather. While climate protocols and policies at the global and national levels are essential, if difficult to achieve, it may be more productive for policymakers to engage with local actions and understandings. Mitigation and adaptation can be advanced through practical initiatives and place-specific information that make the most sense to those living locally.

**Acknowledgments** Appreciation is expressed to survey participants from Lake Macquarie and the Upper Hunter LGAs. Our thanks goes to Sonia Freeman for research assistance, Patrick McElduff for statistical consultation and Gina Krone for editorial help. Support from Lake Macquarie City Council, Upper Hunter Shire Council and Glenn Albrecht is also acknowledged. This research is funded by an Australian Research Council Discovery Project (DP0878089).

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