

Exploring the effect of heat on stated intentions to move

Kerstin K. Zander¹ · Akhilesh Surjan² ·
Stephen T. Garnett³

Received: 26 October 2015 / Accepted: 14 June 2016 / Published online: 25 June 2016
© Springer Science+Business Media Dordrecht 2016

Abstract Climate change is leading to more frequent and longer heat waves and in many places, such as large parts of Australia, to an increase in average temperatures. Rising temperatures can reduce well-being and influence decisions about residency and mobility among people. This study assesses the intentions of a nationally representative sample of working-age people living in Australia to move to somewhere cooler than where they currently live as a response to increasing heat. We found that 11 % of respondents intend to move away from their current place or residence because of increasing temperatures. We also found that men are more likely to intend to move, as are those who feel often stressed by heat, those with a generally high level of mobility, and those who are worried about climate change. Age does not explain movement intentions although it has been found that young people are generally the most mobile, and then those in retirement age again. This means that people formerly expected to be rather immobile might be more likely to intend to move when they feel the local climate has become intolerably hot. Planning for infrastructure and service provision, which has a long lead time, will therefore need adjustment to account for the likely effects of climate change on mobility decisions and settlement patterns.

Electronic supplementary material The online version of this article (doi:10.1007/s10584-016-1727-9) contains supplementary material, which is available to authorized users.

✉ Kerstin K. Zander
kerstin.zander@cdu.edu.au

¹ Northern Institute, Charles Darwin University, Ellengowan Drive, Darwin, Northern Territory, 0909, Australia

² School of Health, Charles Darwin University, Ellengowan Drive, Darwin, Northern Territory, 0909, Australia

³ Research Institute for the Environment and Livelihoods, Charles Darwin University, Ellengowan Drive, Darwin, Northern Territory, 0909, Australia

1 Introduction

Relocation as a form of climate change adaptation, whether voluntary or forced, has been recognised since the first report of the Intergovernmental Panel on Climate Change (IPCC) as well as debated extensively in academic literature (Hugo 2011; McSweeney and Coomes 2011; de Sherbinin et al. 2011). Voluntary relocation in particular can be seen as either a failure of in-situ adaptation or as part of a portfolio of adaptation measures (Bardsley and Hugo 2010; de Sherbinin et al. 2011).

In developing countries climate-related issues such as droughts (Gray and Mueller 2012), floods (Ocello et al. 2015), sea level rise (Perch-Nielsen et al. 2008), heat (Mueller et al. 2014) and broader environmental degradation and change, which includes climate change (Mortreux and Barnett 2009; Bardsley and Hugo 2010; Massey et al. 2010; Warner and Afifi 2014), have all been recognised as having large impacts on movement decisions. In developed countries, such research has largely been limited to Indigenous (First Nation) people (Koppel Maldonado et al. 2013; Zander et al. 2013; King et al. 2014) with a few recent exceptions relating to agricultural activities (McLeman and Ploeger 2012; Spector et al. 2014; Turhan et al. 2015) and sea level rise (Graham et al. 2014).

Instead, most research on planned relocation and migration in developed countries suggests mobility is a function of complex linkages between multiple factors (Landale and Guest 1985; Lu 1998) relating mostly to the job market, family, or housing and other economic push/pull factors (Böheim and Taylor 2007; Coulter and Scott 2015). Satisfaction (or rather dissatisfaction) and life courses are also important aspects why people move (Rossi 1955; Speare 1974; Mulder 2007; Geist and McManus 2008). Climate and environmental considerations have not emerged as drivers, or at least have not been investigated. Empirical research on the role of climate change on mobility¹ of non-Indigenous people in developed countries is thus an important research gap.

Such research is complicated by the diversity of motivations underlying most mobility - environmental change rarely appears to be the sole cause of movements/migration except after an extreme weather event. Instead environmental factors almost always interact with non-environmental factors to drive migration (McLeman and Smit 2006; Tacoli 2009; Black et al. 2011; Renaud et al. 2011). Climate change, including factors like heat, needs to be incorporated into standard mobility models (Neumann and Hilderink 2015) but this can only happen with greater understanding of its influence on decisions to move.

Our study explores intentions to move away from current place of residence to somewhere cooler among a sample of people living in Australia as a consequence of climatic heat, a serious health issue that is being exacerbated by climate change (Kovats and Hajat 2008; Smith et al. 2014; Dong et al. 2015). Such research is particularly important to Australia. Heat-related deaths in Australia, already one of the hottest developed countries, averages 0.55 heat-related deaths per 100,000 people per decade since 1910 (Coates et al. 2014), are increasing each year (Banwell et al. 2012; Coates et al. 2014). Australia's climate has already warmed by 0.9 °C since 1910 and temperatures are projected to rise by 0.6 to 1.5 °C by 2030 compared with the climate of 1980 to 1999 (BoM 2014). Both the duration and frequency of heatwaves increased over the period 1971–2008. As has happened globally (WMO and WHO 2015), the hottest days during heatwaves across most of Australia became even hotter (Perkins and

¹ We use mobility as a broader term covering all types of movements, such as migration and internal movements, residential and temporary (for mobility frameworks, see, for instance, Zelinsky 1971, or Sheller and Urry 2006).

Alexander 2013; Steffen et al. 2014) and the chances of stand-alone hot days are also higher (Min et al. 2013; Perkins and Alexander 2013). A recent study has estimated the annual costs from labour productivity loss related to heat in Australia at USD 6.2 billion (Zander et al. 2015) which is likely to rise with increasing temperatures and increasing nationwide ‘heat health burden’ (Hanna et al. 2011).

The broad aim of our study is to explore the extent to which heat influences intentions to move away from the current place of residence and compare this with other common determinants of moving intentions and mobility. We do so by investigating 1) the extent to which climate change is already causing stress among people living in Australia, 2) more broadly how climate and weather act as drivers of mobility, and 3) the characteristics of those most likely to move away from their current place of residence because of increasing temperatures.

This study is novel by looking not only at the impact of increasing temperatures on mobility but also at peoples’ perceived heat stress. Such data are only available from surveys and cannot be retrieved from census or population databases that underpin most mobility research. Here we used self-reported statements from a national cross-sectional survey about the frequency of past movements and intentions to move in the future. The results of our study can enhance delivery of cohort-specific services and policies.

2 Data and methods

2.1 Reasoned action approach

We focus on intentions to move away from current place of residence voluntarily because of heat, not the actual moving decisions. This intention reflects a willingness to change place of residence (de Jong 1999) and is based on the Reasoned Action Approach (Fishbein and Ajzen 2010) and its antecedents, the Theory of Planned Behaviour (TPB; Ajzen 1991) and the Theory of Reasoned Action (Fishbein and Ajzen 1975). This body of theory posits that an individual’s behaviour is predicated on an intention to act, itself a product of behavioural, normative and control beliefs. The theory has been employed in many disciplines to explain human behaviour, particularly psychology, health, and increasingly, human geography where it is invoked to explain migration intentions (e.g. Manski 1990; Sandu and de Jong 1996; Lu 1998; van Dalen and Henkens 2008; de Groot et al. 2011).

2.2 Data collection, sampling and analysis

Data were collected through a commissioned online survey during two waves in 2014: the last two weeks of May and the first two weeks of October. The sample was drawn from an online panel (MyOpinions PermissionCorp) which has an active panel of ~300,000 respondents. In total 9406 people from the panel were sampled in two waves (see ‘Materials’ in Online Resources for details on sampling, the questionnaire and data analysis). The pivotal question to determine respondent’s intention to move because of heat has been: ‘*Are you intending to move away from where you live now because it is too hot to somewhere cooler?*’ with possible responses Yes or No. We therefore used a logit model with a binary dependent variable which equals one if respondents stated they will move because of heat, and zero otherwise (see Online Resources).

3 Results

3.1 Demographic sample characteristics

After removing incomplete responses, we kept 1839 responses out of the total of 1925. Slightly less than half of the respondents (48 %) were female (Table S2 in Online Resources). Average age was 40.9 years (SD: 12.4), with a median of 41 years, which is slightly higher than the 37 years median age at a national level (ABS 2012). One of the reasons for a higher median is that we only targeted people over 18. Fifty-five percent of respondents said they had children. Most respondents had tertiary education (71 %) and most (94 %) were in paid employment. While our sample represents well the national employment rate (94.5 % across the 18 to 65 years old; ABS 2012), those with university education were, as expected, over-represented (37 % compared with a national average of 24 %; ABS 2012) and those not attaining Year 12 education under-represented (14 % compared to 26 % nationally; ABS 2012).

The average annual personal income was about AUD 60,000 (SD: AUD 82,500) with a median of AUD 50,000 which is very similar to the national median of working people between 18 and 65 (AUD 46,000; ABS 2012). In line with the national population distribution (ABS 2012), about 64 % of the respondents were from the three most populated states and proportionally fewer from the other states/territories (Table S2 in Online Resources).

3.2 Climate change and other concerns

Here we used “being worried for themselves and their families in their local environment” as a proxy for dissatisfaction (see aim 1). With Australia being one of the most expensive countries in which to live (Deutsche Bank 2015), it was not surprising to find that the rising cost of living was the main concern with about 92 % of respondents at least a little bit worried by it (Fig. S1 in Online Resources) with other factors being marginally of greater or lesser concern. Climate change ranked as the fifth most important factor. About 95 % of the population believed climate change is happening, and 83 % believe it to be, at least partly, the result of human agency; the remaining 17 % did not believe in climate change or thought it is caused entirely by natural processes.

3.3 Mobility and its reasons

Respondents were fairly evenly spread among mobility categories (Table S2 in Online Resources). The smallest group (18 %) were highly mobile, i.e. they usually moved once a year (3 %) or every 2–3 years (15 %), a higher proportion were moderately mobile (46 %), moving once every five (20 %) or ten years (26 %) while about a third were relatively sedentary, having never moved in their lives (11 %) or not in the last 15 years (25 %). Younger people were more likely to be highly mobile ($P < 0.001$). The average age of highly mobile people was 33.8 years, that of moderately mobile people 40.8 years and that of people with low mobility 44.5 years (Fig. S2 in Online Resources). Income did not have a significant impact on the degree of mobility but, as expected, in line with mobility theory, employment was the most important reason for respondents who have moved in the past (Fig. S3 in Online Resources). Although weather was the least important of the reasons for past movements within Australia, 41 % of respondents listed it as an important or very important influence in

their decision to move in the past (this can include people moving to warmer as well as cooler climates).

3.4 Moving because of heat

Twenty-seven percent of respondents (495) never felt stressed by heat in their daily lives, 26 % rarely (484), 30 % sometimes (551), 10 % often (179) and 7 % very often (130) (Table S2 in Online Resources). We are confident that the sample has not been unduly influenced by its timing in relation to hot weather because we had undertaken two independent surveys five months apart to reduce the chance of conducting the survey during or soon after particularly hot periods, choosing late May and early October as times when exceptional heat would be unlikely. There were no statistically significant differences between surveys (using Pearson's Chi-squared test and ANOVA) in core demographic variables among respondents nor in their intention to move because of heat (see Table S1 in Online Resources).

Those who were not stressed by heat were not presented with the question about moving because of heat. Another 78 (4 %) did not answer this question and therefore the sample for the following analysis was reduced to 1266 people. From these 1266 respondents who said they had been heat stressed, the majority (89 %; 1133) did not intend to move in the future because of heat while 11 % (133) did. The answer was affected by gender ($P < 0.005$), education ($P < 0.01$), degree of perceived heat stress ($P < 0.001$) and general mobility ($P < 0.001$) but neither by age nor income (Table 1). A higher percentage of male respondents said they would move because of heat than female respondents (13 % vs. 8 %) but this was not related to either the proportion of time spent working outside or the degree of physical exertion ($P = 0.226$ and $P = 0.116$, respectively). People with a university degree would move in 13 % of cases. While this did not differ significantly from the two groups with the lowest levels of education, it was significantly higher than those who had diplomas or trade certificates. Those who often and very often felt stressed by heat in their daily lives would move in 20 % and 28 % of cases, respectively. Irrespective of climatic zone, more than 50 % of men who often felt stressed by heat (combining 'often' and 'very often'), and who were very mobile, said they would move because of heat (Fig. 1). Almost a third (27 %) of men who were often stressed and moderately mobile would move. For women, the percentage stating they would move because of heat exceeded the average when they sometimes

Table 1 Results of a logit model with the dependent variable 'Intending to move because of heat' (0/1); $N = 1266$

	Coeff.	Std. Error	Odds ratio	Odds ratio 2.5 % CI	Odds ratio 95 % CI
Constant	-5.38***	0.42			
Living in northern Australia	1.83***	0.34	6.24	3.17	12.07
Being male	0.56**	0.20	1.74	1.17	2.62
Being very stressed by heat	1.37***	0.20	3.92	2.64	5.84
Being very mobile	0.85***	0.21	2.33	1.52	3.53
Being worried about climate change	0.52***	0.11	1.68	1.36	2.08
Being worried about job security	0.28**	0.10	1.32	1.09	1.62

BIC: 751.149; AIC: 715.13

Significance levels: *** = $p < 0.001$, ** = $p < 0.01$

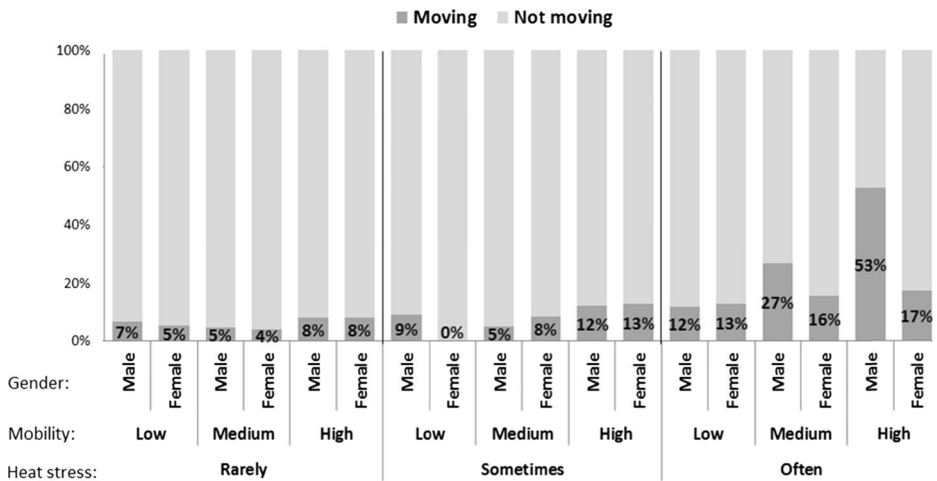


Fig. 1 Percentage of people stating they might move because of heat by gender, general mobility and frequency of feeling stressed by heat ($N = 1266$)

felt stressed by heat in combination with high mobility. A third of respondents living in tropical northern Australia would move, compared to 9 % of those living in the temperate southern zone with the logit model showing the probability of moving of people from the tropical North to be 86 % higher than for people in temperate climates.

Results from the logit model showed that the three variables with most influence on heat related movement intentions were ‘living in the North’, ‘often being stressed by heat’ and ‘being very mobile in general’ (Table 1). The odds for a person intending to move because of heat increased by a factor of more than six when that person lived in the North, which means that a person living in northern Australia had a 86 % ($=6.24/(6.24 + 1)$) higher probability of intending to move because of heat than a person from southern Australia. Respondents who were often stressed by heat (combined ‘often’ and ‘very often’) had an 80 % higher probability of intending to move than those who were stressed by heat less often.

We controlled for gender, age, income and education but gender remained significant after the stepwise procedure. Being a man increased the odds of intending to move because of heat by a factor of 1.7, holding all other factors constant, i.e. men were 63 % times more likely to intend to move because of heat than women. The probability of intending to move was about 1.7 times higher for those who were worried about climate change and 1.3 times higher for those worried about the security of their jobs (compared to those not worried). The level of belief in anthropogenic climate change (see section 3.2), which was similar to the Australian average at the time (83–85 %; Greenhill et al. 2014; Tranter and Booth 2015), did not affect decisions about mobility.

3.5 Moving when?

Of those people who intend to move because of heat, most thought they might move in the distant future (33 %), 17 % in two to three years, 20 % in about a year and 14 % within the next three months. A substantial proportion (16 %) was in the process of moving at the time of the survey. Those who said they would move in the distant future were statistically older ($P < 0.01$) than those thinking of moving within the next three months (mean age 42.6 versus

34.3). Those already in the process of moving were more often stressed by heat than those moving later than within the next three months ($P < 0.005$). Those who would move in the distant future exhibited a lower general mobility than all those who would move earlier ($P < 0.005$). Education, gender, income and location (climatic zone) did not significantly explain the timeframe of potential heat related movements.

4 Discussion

Our results provide one of the few accounts of the general population in a developed economy intending to relocate because of climate change impacts, namely increasing heat. So far most research on mobility because of climate change and natural hazards has taken place in developing countries, or, if in developed countries, then in the context of Indigenous (First Nation) people (e.g. Koppel Maldonado et al. 2013; Zander et al. 2013; King et al. 2014). This is likely to be because of Indigenous peoples' strong dependency on natural resources for their livelihoods and cultural fulfilments, and therefore their high perceived vulnerability to climate change impacts. However, the deadliest heat waves have been in Europe (2003 with about 71,000 deaths) and Russia (2010 with about 56,000 deaths; CRED 2015). This highlights the importance of our research not only for Australia, which is generally hot anyway, but also for the warmer parts of Europe and the USA.

4.1 Who is most likely to intend to move because of heat?

As expected, people who have been highly mobile in the past were more likely to intent to move because of heat. This is consistent with migration intention studies (e.g. de Jong et al. 1985). Similarly, consistent with mainstream mobility studies (e.g. Geist and McManus 2008; Coulter and Scott 2015), younger respondents were more likely to have moved in the past than older people, usually because of employment, education and partners. An unexpected result, however, was that age did not affect the moving intention. Previous studies have shown that movement intentions (mainly international migration) were positively correlated with age (e.g. de Jong et al. 1985; de Groot et al. 2011). This means that heat can influence intentions to move regardless of a person's stage in life. This can have consequences for service provision by altering normal movement patterns. For example, if more middle-aged people in established careers move than would previously have been expected, this could leave a shortage of skills and labour in areas that experience more frequent uncomfortably hot weather.

The reason highly mobile males show a relatively high intention to move because of heat could be related to their occupation which often involves working in labour intensive jobs outside, such as in construction, mining or agriculture (Peiffer and Abbiss 2013; Spector et al. 2014; Turhan et al. 2015). Unsurprisingly this is especially true for places that are hot and humid for much of the year, like tropical northern Australia with a generally mobile population and high labour turn-over rates (e.g. Hall et al. 2007). This is consistent with our finding that people are almost twice as likely to leave tropical Australia because of heat than they are to leave temperate areas.

4.2 Multiple reasons for moving

It is important to understand motivations for moving (Coulter and Scott 2015) with common reasons being family, relationships, social support (Mulder 2007; Geist and McManus 2008)

and employment prospects (Böheim and Taylor 2007). Future changes in climate will be experienced in the context of these multiple, interacting forces, and adaptation initiatives will need to be designed in light of these (Petheram et al. 2010; Mubaya et al. 2012; McCubbin et al. 2015).

While jobs and family will probably remain the two factors most influential in the decisions of respondents to move, with heat subsidiary, steadily increasing temperatures will play an increasingly important role in the future. We show here that for one group of people, mobile males, heat might be already more important than ‘subsidiary’.

4.3 Policy implications

It is unlikely that the influence of climate change, including increasing heat, will be the sole driver of movements in the near future but heat will be mixed with a range of other motivations, barriers and push/pull factors (Bardsley and Hugo 2010; Black et al. 2011). Nevertheless, our research suggests that heat will increasingly impinge on a person’s decision to move, regardless of their age. Indeed, for those most likely to move, heat might be as important for the decision to move as the availability of jobs, services and amenities, and social networks, pivotal push/pull factors of mobility within Australia (see Fig. S3) and elsewhere (Böheim and Taylor 2007; Geist and McManus 2008; Coulter and Scott 2015). Therefore, heat can have important implications for service provision and labour supply, but is often ignored. For instance a policy recently released promoting expansion of both population and development in northern Australia (Australian Government 2015), which is currently sparsely populated, little developed and suffering chronic labour shortages with high turn-over rates (Carson et al. 2010), fails to mention problems relating to heat or climate at all. Our research suggests that recruitment should involve exploration of attitudes and responses to heat, with employment targeting people who are both less mobile in general but also not badly affected by heat. Based on our results, most such people are likely to be women.

A willingness to tolerate hot weather may also increase with appropriate incentives, such as tax concessions or higher incomes. However, living conditions more broadly may need to be managed if heat-related movement is to be contained. For instance, regulations for house design, particularly for the low income groups most likely to be affected by heat waves, can drive heat friendly housing (e.g. Porritt et al. 2012; Barnett et al. 2015; Saman et al. 2015). Similarly mitigation measures such as pavements that block heat and absorb moisture and devices that spray mist on the streets have been installed in Tokyo, an urban heat island (Iizumi and Surjan 2011). Green space can also moderate hot temperatures in urban settings (e.g. Gomez et al. 2004; Yu and Hien 2006). Such heat mitigation measures are likely to play important roles in retaining populations as well as in sustaining urban liveability. As heat increasingly becomes intolerable but people are unwilling to move because of attachment to place, heat relief training and other support measures must be in place. For example Indigenous people with strong connections to their traditional country and families (Rose 1999; Christie and Greatorex 2004), while highly mobile temporarily (Taylor 1997), are deeply reluctant to move away from their traditional land other than for cultural reasons (see e.g. Biddle and Hunter 2006). Similarly farmers with strong connections to their land, occupation and rural lifestyle are likely to resist moving even though heat might have negative consequences on them making a living from farming (e.g. Marshall et al. 2012).

4.4 Limitations and research outlook

There are two aspects of this study that must be taken into account when applying the findings. First, the study is clearly limited by the focus on moving intentions only. It is well known that there are behavioural inconsistencies between an initial stated intention and the final decision to move (Fishbein and Ajzen 1975). However, work on other reasons for migration has shown that behavioural intentions are valid, reliable and commonly used as proxies for actual behaviour (Fishbein and Ajzen 1975; de Jong et al. 1985; Rise et al. 2003; Nawrotzk et al. 2013).

The second limitation relates to the self-reported nature of the data collection, which is common to all survey research methodology (see e.g. Stone et al. 2000). However, our sample is quite large, which helps alleviate biases arising from small self-selected samples. Furthermore, the similarity of the sample's demographic composition to that of the Australian population enables us to make cautious inferences about Australian society as a whole. While there was a slight bias towards people with tertiary degrees, the intention to move was not significantly different to those leaving school before Year 12 so we feel this did not unduly affect the results. Another way of managing bias is to control for causal inferences. In our study we tested for the influence of factors known to affect planned movements in other circumstances and the results were as expected (e.g. general mobility positively influencing the intention to move because of heat).

Our findings point to the need for more comprehensive research in three areas. First, longitudinal studies would provide empirical evidence of the impact of heat on mobility over time, and could compare moving intentions with actual movement behaviour as a response to increasing heat. Second, for service provision planning, further research should extend from hot regions losing population to colder receiving regions within Australia. Third, more research is needed on how those people who are immobile and 'trapped' (see e.g. Adams 2016), and do not move away even as heat becomes intolerable where they live and compromises their livelihoods and well-being, can be helped either to cope with heat or encouraged to move.

5 Conclusions

The message from this research is that heat is not only a reason for moving in developing countries but is also likely to be playing a small but increasing role in decisions about mobility in developed countries like Australia, and in other places where people have the economic, legal and social freedom to relocate. Seven per cent of all respondents (11 % of those stressed by heat) from a broad cross-section of age groups said they would move in the future if the weather became too hot where they were. Heat was a driver of movement intentions for half of the men with a past history of frequent movement and a tendency to find heat stressful. If intentions to move because of heat are acted on as heat rises, labour and skills shortages will be exacerbated, particularly in places that are already hot and thus near comfort limits. Government and employers can respond through monetary and other incentives or by providing services and adjusting regulations but only if they consciously factor in heat as a driver of mobility. Given that rapid increases in temperature are imminent, development of appropriate policy should not be delayed for long.

Author contributions KKZ and STG had the initial idea for the study. KKZ and STG designed the study and KKZ was responsible for data collection and analysis. AK provided conceptual advice and helped with interpretation of data. KKZ and STG wrote the first draft of the paper and all three authors have reviewed the manuscript critically for important intellectual content. All authors have given final approval of this version to be published.

References

- ABS (Australian Bureau of Statistics) (2012) Census of population and housing - 2011. Data generated using ABS table builder. Commonwealth of Australia, Canberra
- Adams H (2016) Why populations persist: mobility, place attachment and climate change. *Popul Environ* 37: 429–448
- Ajzen I (1991) The theory of planned behaviour. *Organ Behav Hum Dec* 50:179–211
- Australian Government (2015) Our north, our future: white paper on developing northern Australia. Australian Government, Canberra. <http://northernaustralia.infrastructure.gov.au/white-paper>. Accessed 12 October 2015
- Banwell C, Dixon J, Bambrick H, Edwards F, Kjellstrom T (2012) Socio-cultural reflections on heat in Australia with implications for health and climate change adaptation. *Glob Health Action* 5. doi:10.3402/gha.v5i0.19277
- Bardsley DK, Hugo GJ (2010) Migration and climate change: examining thresholds of change to guide effective adaptation decision-making. *Popul Environ* 32:238–262
- Barnett G, Beaty RM, Meyers J, Chen D, McFallan S (2015) Pathways for adaptation of low-income housing to extreme heat. In: Palutikof JP, Boulter SL, Barnett J, Rissik D (eds) *Applied studies in climate adaptation*. Wiley-Blackwell, Oxford, pp. 364–371
- Biddle N, Hunter B (2006) An analysis of the internal migration of indigenous and non-indigenous Australians. *Australian J Lab Econ* 9:321–341
- Black R, Adger WN, Arnell NW, Dercon S, Geddes A, Thomas D (2011) The effect of environmental change on human migration. *Glob Environ Chang* 21:S3–S11
- Böheim R, Taylor MP (2007) From the dark end of the street to the bright side of the road? The wage returns to migration in Britain. *Labour Econ* 14:99–117
- Bureau of Meteorology (BoM) (2014) State of the climate 2014. BoM and CSIRO, Canberra
- Carson D, Coe K, Zander K, Garnett ST (2010) Does the type of job matter? Recruitment to Australia's northern territory. *Employee Relat* 32:121–137
- Centre for Research on the Epidemiology of Disasters (CRED) (2015) Emergency Events Database EM-DAT, Brussels <http://www.emdat.be>. Accessed 12 October 2015
- Christie M, Greatorex J (2004) Yolngu life in the northern territory of Australia: the significance of community and social capital. *Asia Pac J Public Health* 26:55–69
- Coates L, Haynes K, O'Brien J, McAneney J, Dimer de Oliveira F (2014) Exploring 167 years of vulnerability: an examination of extreme heat events in Australia 1844–2010. *Environ Sci Pol* 42:33–44
- Coulter R, Scott J (2015) What motivates residential mobility? Re-examining self-reported reasons for desiring and making residential moves. *Popul Space Place* 21:354–371
- de Groot C, Mulder CH, Das M, Manting D (2011) Life events and the gap between intention to move and actual mobility. *Environ Plan A* 43:48–66
- de Jong GF (1999) Choice process in migration behaviour. In: Pandit K, Withers S (eds) *Migration and restructuring in the united states*. Rowman and Littlefield, Lanham, pp. 273–293
- de Jong G, Root BD, Gardner RW, Fawcett JT, Abad RG (1985) Migration intentions and behaviour: decision making in a rural Philippine province. *Popul Environ* 8:41–62
- de Sherbinin A, Castro M, Gemenne F, Cernea MM, Adamo S, Fearnside PM, Krieger G, Lahmani S, Oliver-Smith A, Pankhurst A, Scudder T, Singer B, Tan Y, Wannier G, Boncour P, Ehrhart C, Hugo G, Pandey B, Shi G (2011) Preparing for resettlement associated with climate change. *Science* 28:456–457
- Deutsche Bank (2015) The random walk: mapping the world's prices. Hong Kong. http://ftalphaville.ft.com/files/2015/04/DB_RandomWalk_2015-04-14_0900b8c0898020b1-1.pdf. Accessed 12 October 2015
- Dong W, Liu Z, Liao H, Tang Q, Li X (2015) New climate and socio-economic scenarios for assessing global human health challenges due to heat risk. *Clim Chang* 130:505–518
- Fishbein M, Ajzen I (1975) Belief, attitude, intention, and behavior: an introduction to theory and research. Addison-Wesley, Reading
- Fishbein M, Ajzen I (2010) Predicting and changing behavior: the reasoned action approach. Taylor & Francis, New York

- Geist C, McManus P (2008) Geographical mobility over the life course: motivations and implications. *Popul Space Place* 14:283–303
- Gomez F, Gil L, Jabaloyes J (2004) Experimental investigation on the thermal comfort in the city: relationship with the green areas, interaction with the urban microclimate. *Build Environ* 39:1077–1086
- Graham S, Barnett J, Fincher R, Hurlimann A, Mortreux C (2014) Local values for fairer adaptation to sea-level rise: a typology of residents and their lived values in lakes entrance, Australia. *Glob Environ Chang* 29:41–52
- Gray C, Mueller V (2012) Drought and population mobility in rural Ethiopia. *World Dev* 40:134–145
- Greenhill M, Leviston Z, Leonard R, Walker I (2014) Assessing climate change beliefs: response effects of question wording and response alternatives. *Public Underst Sci* 23:947–965
- Hall D, Garnett S, Barnes T, Stevens M (2007) Drivers of professional mobility in the northern territory: dental professionals. *Rural Remote Health* 7:655
- Hanna E, Kjellstrom T, Bennett C, Dear K (2011) Climate change and rising heat: population health implications for working people in Australia. *Asia Pac J Public Health* 23:14–26
- Hugo G (2011) Future demographic change and its interactions with migration and climate change. *Glob Environ Chang* 21:S21–S33
- Iizumi A, Surjan A (2011) Initiatives towards reducing the impacts of the urban heat island in Tokyo. In: Rosenzweig C, Solecki WD, Hammer SA, Mehrotra S (eds) *Climate change and cities: first assessment report of the urban climate change research network*. Cambridge University Press, Cambridge, pp. 240–241
- King D, Bird D, Haynes K, Boon H, Cottrell A, Millar J, Okada T, Box P, Keogh D, Thomas M (2014) Voluntary relocation as an adaptation strategy to extreme weather events. *Int J Disaster Risk Reduction* 8:83–90
- Koppel Maldonado J, Shearer C, Bronen R, Peterson K, Lazrus H (2013) The impact of climate change on tribal communities in the US: displacement, relocation, and human rights. *Clim Chang* 120:601–614
- Kovats RS, Hajat S (2008) Heat stress and public health: a critical review. *Annu Rev Public Health* 29:41–55
- Landale N, Guest A (1985) Constraints, satisfaction and residential mobility: Speare's model reconsidered. *Demography* 22:199–222
- Lu M (1998) Analyzing migration decisionmaking: relationships between residential satisfaction, mobility intentions, and moving behavior. *Environ Plan A* 30:1473–1495
- Manski CF (1990) The use of intentions data to predict behavior: a best-case analysis. *J Am Stat Assoc* 85:934–940
- Marshall NA, Park SE, Adger WN, Brown K, Howden SM (2012) Transformational capacity and the influence of place and identity. *Environ Res Lett* 7:034022
- Massey DS, Axinn WG, Ghimire DJ (2010) Environmental change and out-migration: evidence from Nepal. *Popul Environ* 32:109–136
- McCubbin S, Smit B, Pearce T (2015) Where does climate fit? Vulnerability to climate change in the context of multiple stressors in Funafuti, Tuvalu. *Glob Environ Chang* 30:43–55
- McLeman RA, Ploeger SK (2012) Soil and its influence on rural drought migration: insights from depression-era southwestern Saskatchewan, Canada. *Popul Environ* 33:304–332
- McLeman R, Smit B (2006) Migration as an adaptation to climate change. *Clim Chang* 76:31–53
- McSweeney K, Coomes OT (2011) Climate-related disaster opens a window of opportunity for rural poor in northeastern Honduras. *P Natl Acad Sci* 108:5203–5208
- Min S-K, Cai W, Whetton P (2013) Influence of climate variability on seasonal extremes over Australia. *J Geophys Res-Atmos* 118:643–654
- Mortreux C, Barnett J (2009) Climate change, migration and adaptation in Funafuti, Tuvalu. *Glob Environ Chang* 19:105–112
- Mubaya CP, Njuki J, Mutsvangwa EP, Mugabe FT, Nanja D (2012) Climate variability and change or multiple stressors? Farmer perceptions regarding threats to livelihoods in Zimbabwe and Zambia. *J Environ Manag* 102:9–17
- Mueller V, Gray C, Kosec K (2014) Heat stress increases long-term human migration in rural Pakistan. *Nat Clim Chang* 4:182–185
- Mulder CH (2007) The family context and residential choice: a challenge for new research. *Popul Space Place* 13:265–278
- Nawrotzk RJ, Brenkert-Smith H, Hunter LM, Champ PA (2013) Wildfire-migration dynamics: lessons from Colorado's Fourmile canyon fire. *Soc Nat Resour* 27:215–225
- Neumann K, Hilderink H (2015) Opportunities and challenges for investigating the environment-migration nexus. *Hum Ecol* 43:309–322
- Ocello C, Petrucci A, Testa M, Vignoli D (2015) Environmental aspects of internal migration in Tanzania. *Popul Environ* 37:99–108
- Peiffer JJ, Abbiss CR (2013) Thermal stress in north western Australian iron ore mining staff. *Ann Occup Hyg* 57:519–527

- Perch-Nielsen SL, Bättig MB, Imboden D (2008) Exploring the link between climate change and migration. *Clim Chang* 91:375–393
- Perkins S, Alexander L (2013) On the measurement of heat waves. *J Clim* 26:4500–4517
- Petheram L, Zander KK, Campbell B, High D, Stacey N (2010) ‘strange changes’: indigenous perspectives of climate change and adaptation in NE Arnhem land (Australia). *Glob Environ Chang* 20:681–692
- Porritt SM, Cropper PC, Shao L, Goodier C (2012) Ranking interventions to reduce dwelling overheating during heat waves. *Energy Buildings* 55:16–27
- Renaud FG, Dun O, Warner K, Bogardi J (2011) A decision framework for environmentally induced migration. *Int Migr* 49:e5–e29
- Rise J, Thompson M, Verplanken B (2003) Measuring implementation intentions in the context of the theory of planned behavior. *Scand J Psychol* 44:87–95
- Rose DB (1999) Indigenous ecologies and an ethic of connection. In: Low N (ed) *Global ethics and environment*. Routledge, London, pp. 175–187
- Rossi PH (1955) *Why families move*. Free Press, Glencoe
- Saman W, Pullen S, Boland J (2015) How to cope with heat waves in the home. In: Palutikof JP, Boulter SL, Barnett J, Rissik D (eds) *Applied studies in climate adaptation*. Wiley-Blackwell, Oxford, pp. 354–363
- Sandu D, de Jong GF (1996) Migration in market and democracy transition: migration intentions and behaviour in Romania. *Popul Res Policy Rev* 15:437–457
- Sheller M, Urry J (2006) The new mobilities paradigm. *Environ Plan A* 38:207–226
- Smith KR, Woodward A, Campbell-Lendrum D, Chadee DD, Honda Y, et al. (2014) Human health: impacts, adaptation, and co-benefits. In: Field CB, et al. (eds) *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, pp 709–754
- Speare A (1974) Residential satisfaction as an intervening variable in residential mobility. *Demography* 11:173–188
- Spector JT, Krenz J, Rauser E, Bonauto DK (2014) Heat-related illness in Washington state agriculture and forestry sectors. *Am J Ind Med* 57:881–895
- Steffen W, Hughes L, Pearce A (2014) Heatwaves: hotter, longer, more often. Public Climate Council of Australia Limited. <http://www.climatecouncil.org.au/uploads/7be174fe8c32ee1f3632d44e2cef501a.pdf>. Accessed 12 October 2015
- Stone AA, Bachrach CA, Jobe JB, Kurtzman HS, Cain VS (2000) The science of self-report: implications for research and practice. Lawrence Erlbaum Associates, Mahwah
- Tacoli C (2009) Crisis or adaptation? Migration and climate change in a context of high mobility. *Environ Urban* 21:513–525
- Taylor J (1997) The contemporary demography of indigenous Australians. *J Aust Pop Ass* 14:77–114
- Tranter BK, Booth KI (2015) Scepticism in a changing climate: a cross-national study. *Glob Environ Chang* 33: 154–164
- Turhan E, Zografos C, Kallis G (2015) Adaptation as biopolitics: why state policies in Turkey do not reduce the vulnerability of seasonal agricultural workers to climate change. *Glob Environ Chang* 31:296–306
- van Dalen HP, Henkens K (2008) Emigration intentions: mere words or true plans? explaining international migration intentions and behavior. *CentER Discussion Paper 2008–60*, Center for Economic Research, Tilburg University
- Warner K, Afifi T (2014) Where the rain falls: evidence from 8 countries on how vulnerable households use migration to manage the risk of rainfall variability and food insecurity. *Clim Dev* 6:1–17
- WMO, WHO (2015) Heatwaves and health: guidance on warning-system development. World Meteorological Organization and World Health Organization. <http://www.who.int/globalchange/publications/heatwaves-health-guidance/en>. Accessed 12 October 2015
- Yu C, Hien WN (2006) Thermal benefits of city parks. *Energy Buildings* 38:105–120
- Zander KK, Petheram L, Gamett ST (2013) Stay or leave? - potential climate change adaptation strategies among aboriginal people in coastal communities in northern Australia. *Nat Hazards* 67:591–609
- Zander KK, Botzen WJW, Oppermann E, Kjellstrom T, Gamett ST (2015) Heat stress causes substantial labour productivity loss in Australia. *Nat Clim Chang* 5:647–651
- Zelinsky W (1971) The hypothesis of the mobility transition. *Geogr Rev* 61:219–249