

## University of Groningen

### Psychological research and global climate change

Clayton, Susan; Devine-Wright, P.; Stern, P.; Whitmarsch, L.; Carrico, A.; Steg, Linda; Swim, J.; Bonnes, M.

*Published in:*  
 Nature climate change

*DOI:*  
[10.1038/nclimate2622](https://doi.org/10.1038/nclimate2622)

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*  
 Publisher's PDF, also known as Version of record

*Publication date:*  
 2015

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Clayton, S., Devine-Wright, P., Stern, P., Whitmarsch, L., Carrico, A., Steg, L., Swim, J., & Bonnes, M. (2015). Psychological research and global climate change. *Nature climate change*, 5, 640-646. <https://doi.org/10.1038/nclimate2622>

#### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

#### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

*Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.*

# Psychological research and global climate change

Susan Clayton<sup>1\*</sup>, Patrick Devine-Wright<sup>2</sup>, Paul C. Stern<sup>3</sup>, Lorraine Whitmarsh<sup>4</sup>, Amanda Carrico<sup>5</sup>, Linda Steg<sup>6</sup>, Janet Swim<sup>7</sup> and Mirilia Bonnes<sup>8</sup>

**Human behaviour is integral not only to causing global climate change but also to responding and adapting to it. Here, we argue that psychological research should inform efforts to address climate change, to avoid misunderstandings about human behaviour and motivations that can lead to ineffective or misguided policies. We review three key research areas: describing human perceptions of climate change; understanding and changing individual and household behaviour that drives climate change; and examining the human impacts of climate change and adaptation responses. Although much has been learned in these areas, we suggest important directions for further research.**

Global climate change is one of the major threats facing humanity. Human interactions with climate occur at all levels of social organization<sup>1</sup>, but so far research has focused largely on institutional actors (for example, governments, industries) and on the technological, demographic and economic trends that drive climate change. Factors that influence decisions and behaviour at the individual level have received significantly less attention<sup>2</sup>. However, individual behaviour is important<sup>3</sup> and ultimately drives societal change via adoption of technologies and support for policies. Unless we examine how people perceive climate change, what factors influence mitigation and adaptation behaviours and how climate change will affect human well-being, we will be unable to respond effectively as a society. Too much policy is based on oversimplifications and erroneous assumptions about these factors, for example, the assumption that informing individuals about climate change science is sufficient to affect decisions and behaviours<sup>4–6</sup>. Ignoring insights from psychological research can handicap progress towards a low-carbon, sustainable future<sup>7,8</sup>.

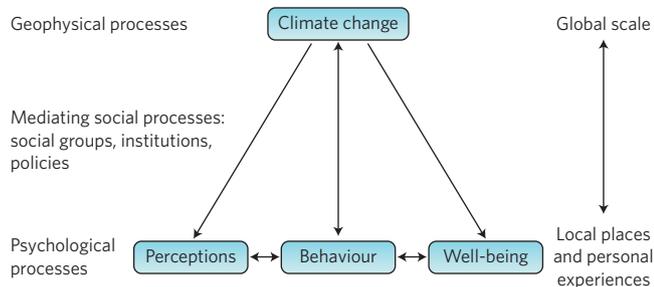
Here, we review the unique contribution that a psychological approach<sup>9,10</sup> can provide for understanding and addressing climate change, complementing work from other disciplines. Psychological research employs rigorous empirical methods to investigate individual perceptions and cognitions, individual and collective behaviours, and psychological well-being related to climate change. This research incorporates physiological, cognitive, affective and interpersonal processes, as well as factors in the social, cultural, biophysical and engineered environments of individuals<sup>5,11</sup>. Some of the resulting insights are surprising or counterintuitive; in other instances, they serve as a reminder to consider factors that may be overlooked. Here we focus on three key areas in which psychological research contributes to the climate change literature: (1) public perceptions of climate change; (2) human behavioural drivers of climate change and mitigation responses; and (3) impacts of climate change on human well-being and adaptation responses (Fig. 1). In each case, we review existing research and recommend key directions for future research. We conclude by considering the ways that psychologists can contribute to multi- and interdisciplinary teams to understand and inform climate change mitigation and adaptation.

## Understanding public perceptions of climate change

There is great variability in public understanding of climate change and willingness to support action. Counterintuitively, public acknowledgement of the problem is not purely a function of education or knowledge and has not grown along with the scientific consensus<sup>12,13</sup>. It is important to understand why people do or do not endorse the need to address climate change, especially in countries with relatively low levels of agreement<sup>14,15</sup>. Psychological research shows that much diversity in understanding can be attributed not to what we learn about climate change but to how, and from whom, we learn: the sources of our information and how we evaluate those sources. In general, direct experiences of events related to climate change are more powerful than second-hand information in informing attitudes and behaviour<sup>16,17</sup>, which in part explains why local, observable conditions (including environmental risks, such as air pollution) typically influence concerns more than distant ones, such as climate change<sup>18</sup>. Yet global warming beliefs also influence assessment of changes in local climatic conditions: for example, national survey data from the USA revealed that, compared with people who accepted the reality of global warming, people who believed that global warming was not happening were less likely to remember (accurately) that they had experienced a warmer-than-usual summer during the previous year<sup>19</sup>. This shows that the effect of experience on perceptions of climate change is moderated by other factors (Fig. 2). Thus, one must also look to other sources of influence on beliefs, attitudes and behaviours related to climate change.

**Climate change communication.** Psychological research highlights that, for messages to be attended and responded to, sources must be trusted and attractive; the message relevant, clear and coherent; and the audience motivated and able to act<sup>20</sup>. This is also evident from the growing literature on persuasive communication about climate change<sup>21</sup>. In many countries, the primary source of information on climate change is the mass media<sup>18</sup>. Where media outlets are associated with differing ideologies or communities of interest and present different views, people tend to preferentially accept the views of trusted and attitudinally reinforcing information sources, while other information sources are ignored and discounted. Partly for this reason, social and political identities are critical determinants

<sup>1</sup>Psychology Department, College of Wooster, 930 College Mall, Wooster, Ohio 44691, USA. <sup>2</sup>Geography, College of Life and Environmental Sciences, University of Exeter, Rennes Drive, Exeter EX4 4RJ, UK. <sup>3</sup>National Research Council, National Academy of Sciences, 500 Fifth Street NW, K-1127, Washington DC 20001, USA. <sup>4</sup>School of Psychology, Cardiff University, 70 Park Place, Cardiff CF10 3AT, UK. <sup>5</sup>Environmental Studies Program, University of Colorado, 1201 17th Street, 397 UCB, Boulder, Colorado 80309, USA. <sup>6</sup>Department of Social Psychology, University of Groningen, Grote Kruisstraat 2/1, 9712 TS Groningen, the Netherlands. <sup>7</sup>Department of Psychology, Pennsylvania State University, University Park, Pennsylvania 16802-3106, USA. <sup>8</sup>Social and Developmental Psychology, Sapienza University of Rome, Piazzale Aldo Moro 5, 00185 Rome, Italy. \*email: sclayton@wooster.edu



**Figure 1 | A schematic model of the role of psychological processes in climate change.** The bidirectional arrow linking climate change to behaviour and the links between perceptions, behaviour and well-being highlight the need to attend to individual-level processes.

of climate change perceptions in many countries<sup>15</sup>. National surveys show an increasing divergence between voters on the left and those on the right in the USA<sup>22</sup> and, to some extent, in the UK<sup>23</sup>; individuals with right-of-centre politics, or with belief systems that emphasize individual autonomy rather than collective ties, are most rejecting of mainstream climate science, less likely to engage in behavioural change and less likely to support policies for action to limit climate change<sup>24</sup>. Indeed, at least in the USA and UK, acceptance versus rejection of climate science seems to be linked far more to political ideology and worldview than to any other factor, and that polarization has increased over time<sup>25</sup>. Regression analyses of survey data show that political party identification is a major predictor of climate change beliefs, even when controlling for ideology<sup>26</sup>, demonstrating that this is a function of group identity and not just of a shared belief system. However, although political polarization and significant scepticism are apparent in countries where there are interest-based efforts to shape public opinion (that is, by conservative think tanks and media outlets<sup>22,27</sup>), other regions, such as Latin America and sub-Saharan Africa, show higher and growing levels of concern with little apparent scepticism or ideological polarization<sup>12</sup>. These findings critically underscore the importance of attending to the social processes that direct people towards particular sources of information, and of considering how to provide information through multiple channels to reach different audiences<sup>28</sup>.

**Motivational processes and cognitive biases.** The discomfort caused by the profound political, ethical and social implications of climatic change can lead climate change messages to be rejected. Political and other identities do more than suggest which information sources are trustworthy; research shows that they also provide people with the mental models that shape their understandings and motivate particular interpretations of the information that is received, which is filtered through lenses of values and identities<sup>29</sup>. Rejection of the scientific consensus can be linked to the perceived threat to one's current way of life that is associated with policies aimed to combat climate change<sup>14</sup>. For example, Americans who read an article that attributed climate change to China's excess energy use were more likely to attribute climate change to human behaviour than were those who read an article attributing it to American excess energy use<sup>30</sup>. These motivational biases can work in concert with biases in information processing to create resistance to climate change information. The 'availability heuristic' in human cognition suggests that risk perceptions will be influenced by recent or common events that are more cognitively 'available'<sup>31</sup>. Survey and experimental evidence shows that concern about climate change increases with current media coverage, sometimes coupled with direct experience such as fluctuations in local weather conditions<sup>32,33</sup>. Tendencies to be overly optimistic about the future, and to focus on the present rather than the future, are other biases that threaten people's ability and motivation to respond in effective

ways to long-term, gradually developing environmental changes and related threats. Ample research suggests that perceptions of risk are heavily conditioned by mental shortcuts, emotions, environmental cues, social experiences and contextual factors<sup>34</sup>.

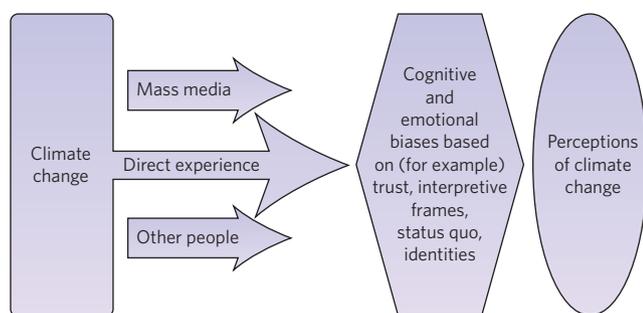
Misperceptions tend to persist because individuals interpret messages in light of previous experience, beliefs, values and expectations, and to seek out information that confirms rather than tests their beliefs<sup>35</sup>. In one study, people who accepted or rejected the idea of climate change were asked to read two articles, one presenting mainstream climate science, and the other a climate sceptic view. The rejecters perceived the sceptical article as more reliable than the non-sceptical article, whereas the reverse was found for the accepters; importantly, both groups reported becoming more convinced of their views<sup>36</sup>. Even misperceptions about climate change that are not value-laden — such as conflation with ozone depletion — endure if they are not directly counteracted because new information is fitted into existing conceptual frameworks<sup>37</sup>.

**Future research directions.** First, this evidence indicates a need to further examine relevant social identities, to better understand how beliefs about climate change have become ideologically polarized in certain populations, and to develop educational interventions and communications tailored to the values and possible misperceptions of specific audiences<sup>38</sup>. Second, we need more research into the ways known information-processing biases affect responses to climate change. For example, discounting of the future may be less prominent in the environmental domain than elsewhere<sup>39,40</sup>.

### Behavioural drivers and mitigation responses

Analyses of household emissions as drivers of climate change, and of ways to reduce them, have traditionally focused on consumer technologies that use fossil fuels (for example, building, automotive and appliance technologies), technologies that would reduce this usage and the economic forces affecting their adoption and use. Psychological concepts complement such analyses by examining non-economic predictors of adoption and use of these technologies, including cognitive and motivational factors such as values and beliefs, and social factors such as norms and public commitments, as well as features of programmes intended to influence behaviour such as the type of information and forms of financial incentive provided. Research shows that these factors differ in relative importance for different types of behaviour, such as household adoption, use and maintenance of consumer technologies, and behaviour in different domains<sup>5,6,41–43</sup>. With some types of behaviour, research has shown that intrinsic factors (for example, values) are often more important than extrinsic ones (for example, incentives)<sup>5,41,44,45</sup>. It is important to recognize that many behavioural decisions are influenced by factors outside conscious awareness<sup>46</sup> (Fig. 3). To the extent that behavioural choices are made in conscious response to the threat of climate change, the factors discussed in the previous section on perceptions will be relevant; however, a great deal of environmentally relevant behaviour is driven by forces such as norms, habits and default options.

**Reducing use of energy-consuming technologies.** Important behavioural choices in technology use include the use of private automobiles versus other travel modes, levels of home heating and cooling, and usage of household appliances, including time of use of electricity. Behavioural analyses of such choices have been conducted since the 1970s and have developed in sophistication over time alongside improved technologies for monitoring and delivering energy-use information to consumers, such as 'smart' meters and in-vehicle consumption feedback devices. Information in the form of feedback on one's energy use relative to past performance or other people's performance has successfully reduced energy use



**Figure 2 | A simplified model of the way people perceive climate change.**

Cognitive and motivational biases moderate the relationship between direct and indirect experiences on the one hand, and perceptions on the other.

in some cases<sup>44,47,48</sup>, but it can backfire. Field experiments in which people are randomly assigned to receive feedback about their neighbours' consumption show that people may increase their energy use when the feedback reveals that they are outperforming others<sup>49</sup>, indicating the important role of social norms in moderating the impact of feedback on behaviour.

Policies seek to influence consumer decisions about technology use by providing information, for example, via energy efficiency labels that make consumers aware of the fossil energy used by the appliance or embodied in the supply chains of what they purchase<sup>50</sup>. Psychological studies can improve the effectiveness of this approach<sup>6,51</sup>, for example, by determining whether tying information about energy use to environmental or financial motives influences its effectiveness. Overall, however, research shows that information has greater impacts on behaviour if it is tailored to the personal situations of consumers and resonates with their important values<sup>52</sup>. Social influence approaches (for example, making a public commitment or observing role models) can also be influential in reducing emissions<sup>44,47</sup>. The 'block leader' approach, which capitalizes on social networks by engaging volunteers in a particular neighbourhood to deliver the interventions, inform neighbours on specific issues and offer assistance in realizing the intended changes, can be particularly effective<sup>44</sup>. In general, people are more likely to engage in energy-use reduction when they have strong self-transcendence values (that is, values that stress protecting the natural environment or causes such as social justice), self-identify as a pro-environmental person, are aware of (energy-related) problems caused by their behaviour, feel morally obliged to engage in energy-saving behaviours, have favourable attitudes towards energy savings, feel capable of engaging in these behaviours and have a social context that supports their behaviours<sup>5,41,44,45</sup>.

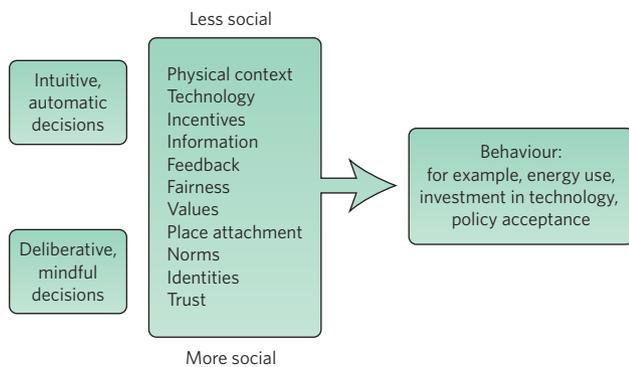
**Inducing investment in low-emissions technologies.** Research shows that households seriously underinvest in low- or zero-carbon technologies<sup>3</sup> compared with the level of investment that would lower optimally their overall costs — what has been called the energy-efficiency gap<sup>53,54</sup>. Much of this gap is due to non-financial factors that can be altered to increase consumer responsiveness to incentives. For example, response to incentive programmes for home insulation implemented by different organizations has varied by a factor of ten or more, depending on trust in the organizations, approaches to marketing and programme implementation, including levels of effort required of the household to take advantage of the incentives<sup>55</sup>. Programme design must attend carefully to processes of thinking and decision making within the target households<sup>56,57</sup>. Although financial incentives can be influential, attention to these cognitive processes can suggest complements to existing or new financial incentives, and are especially important when the latter are not an option<sup>58</sup>.

Psychological research has been particularly useful in revealing the limitations of financial inducements, whose effects often last only as long as the incentives are in place<sup>47</sup>. When the goal is a one-time technology purchase, this may be sufficient. However, focusing individuals' attention on possible financial gain may reduce their engagement in subsequent sustainable actions, as their emphasis shifts from doing good to gaining a profit<sup>59</sup>. In one field experiment, people responded less strongly to an economic appeal (to get their tyre pressure checked) than to a nature-focused or even a neutral appeal<sup>152</sup>. Research shows that non-financial factors, such as the symbolic value of a behaviour as an expression of identity or status and beneficial effects to the environment, may have greater effects on adoption and on use than prices and costs for some kinds of low-emissions technology<sup>60,61</sup>. This is particularly true when possible financial benefits are small relative to the effort needed to gain them<sup>52,62</sup>.

**Public acceptance of technologies and policies.** Psychological research informs understanding of 'not in my back yard' (NIMBY) responses<sup>63</sup> to nearby energy projects, which lead individuals and communities to oppose local development of wind farms or oil and gas extraction<sup>64</sup>. People form strong emotional bonds with a place (place attachments) and may develop a sense of self that is tied to the place (place identities)<sup>65</sup>. Research shows that responses to a range of energy technologies, including offshore wind farms<sup>66</sup> and power lines<sup>67</sup>, are rooted in people-place bonds in complex ways, so that technologies perceived to maintain or enhance the distinctive qualities of a place are supported by individuals with strong place attachments and identities, whereas technologies perceived to threaten those qualities are opposed. Thus renewable energy sources are evaluated not just in terms of objective costs and benefits but also in terms of their perceived fit with the local (natural and socially defined) environment. Responses are also explained by values, levels of trust in project developers, and the perceived fairness of both decision-making procedures and how costs and benefits are distributed<sup>64,67</sup>.

One of the most important ways in which individuals can have an impact is through collective action, such as support for public policies and social movements to reduce greenhouse gases on larger scales through participating in demonstrations, making financial contributions to social movements, signing petitions and voting<sup>43</sup>. Studies suggest that policies that reward people for energy-saving behaviour and adoption of energy-efficient technologies are more acceptable than policies punishing high energy use or promoting curtailment behaviour<sup>68</sup>. Policy acceptance is affected by beliefs about the seriousness of relevant environmental problems, beliefs about the personal and environmental consequences of policies, the extent to which people think they can help reduce these problems, and their feelings of moral obligation to help reduce these problems<sup>69,70</sup>. People evaluate policies positively or negatively depending on how much they trust the responsible institutions and how they believe the policies will affect important values. Perceived justice and fairness, affected both by policy attributes and individual perceptions, can strongly affect responses to policies<sup>69,71</sup>; in some populations, policies are evaluated as more acceptable and fair when people believe that future generations, nature and the environment are protected (reflecting environmental justice), and when everybody would be equally affected<sup>72</sup>.

**Future research directions.** First, research could further study the role of non-financial factors influencing high-impact household behaviours that could mitigate climate change, particularly the adoption of environmentally friendly technologies, and the ways in which these factors interact with monetary inducements. Second, more work is needed by psychologists in collaboration with political scientists and sociologists to illuminate the gap between individual



**Figure 3 | Influences on climate-relevant behaviour.** Principal influences on behaviour will differ depending on whether the behavioural decision is mindful or automatic.

action and societal impact by identifying the circumstances in which individuals take action, alone or collectively, that can bring about large-scale policy changes.

### Impacts on human well-being and adaptation responses

Human behavioural changes are necessary not only to mitigate the effects of climate change but also to adapt to them. Climate change will affect psychological health and well-being in ways that are often overlooked. Abrupt environmental events, experienced as natural disasters, will have direct impacts on mental health and quality of life; in addition, indirect impacts will result from gradually evolving and often cumulative environmental stresses on livelihoods, economic opportunity and sociocultural conditions<sup>73,74</sup> (Fig. 4). Awareness of these impacts can encourage public engagement and inform attempts to encourage effective adaptations that minimize negative effects and capitalize on possibilities for more positive changes.

**Direct and indirect impacts.** Climate change is likely to increase the frequency, extent, or intensity of extreme weather events such as heat waves, drought and flooding<sup>75</sup>, producing many social stresses<sup>76</sup>. Owing to traumatic experiences, loss of loved ones, economic disruption and so on, abrupt disaster events can lead to anxiety, depression, post-traumatic stress disorder and other negative psychological outcomes<sup>77,78</sup>. Such events also disrupt the social and institutional systems that promote health and well-being, including informal social networks and organized mental health services, although disasters sometimes increase social solidarity as communities come together to address the consequences. Negative impacts are more likely for those in the developing world and those who are economically or socially marginalized, exacerbating inequality and resentment, and increasing the likelihood of individual and societal conflict<sup>79,80</sup>. Slowly evolving changes in environmental conditions will also have significant impacts. Gradual increases in temperature and shifts in rainfall patterns will affect livelihood opportunities and local economies, placing many at risk of economic loss, food insecurity and the psychological impacts that result. Both gradual and abrupt environmental changes can result in migrations and forced displacement<sup>81</sup>, which can lead to a range of social and psychological impacts, including feelings of anxiety, grief and loss, and disruption to networks of support and belonging<sup>82</sup>. Policymakers often ignore these potential impacts<sup>83</sup>, although there is increasing attention to them among the military. (See, for example, the 2014 climate change adaptation roadmap from the US Department of Defense, available at <http://go.nature.com/CfT3Ff>)

**Adaptation responses.** People will need to alter their behaviour to adapt to an altered climate. There has been extensive consideration of the economic factors that affect the capacity of individuals

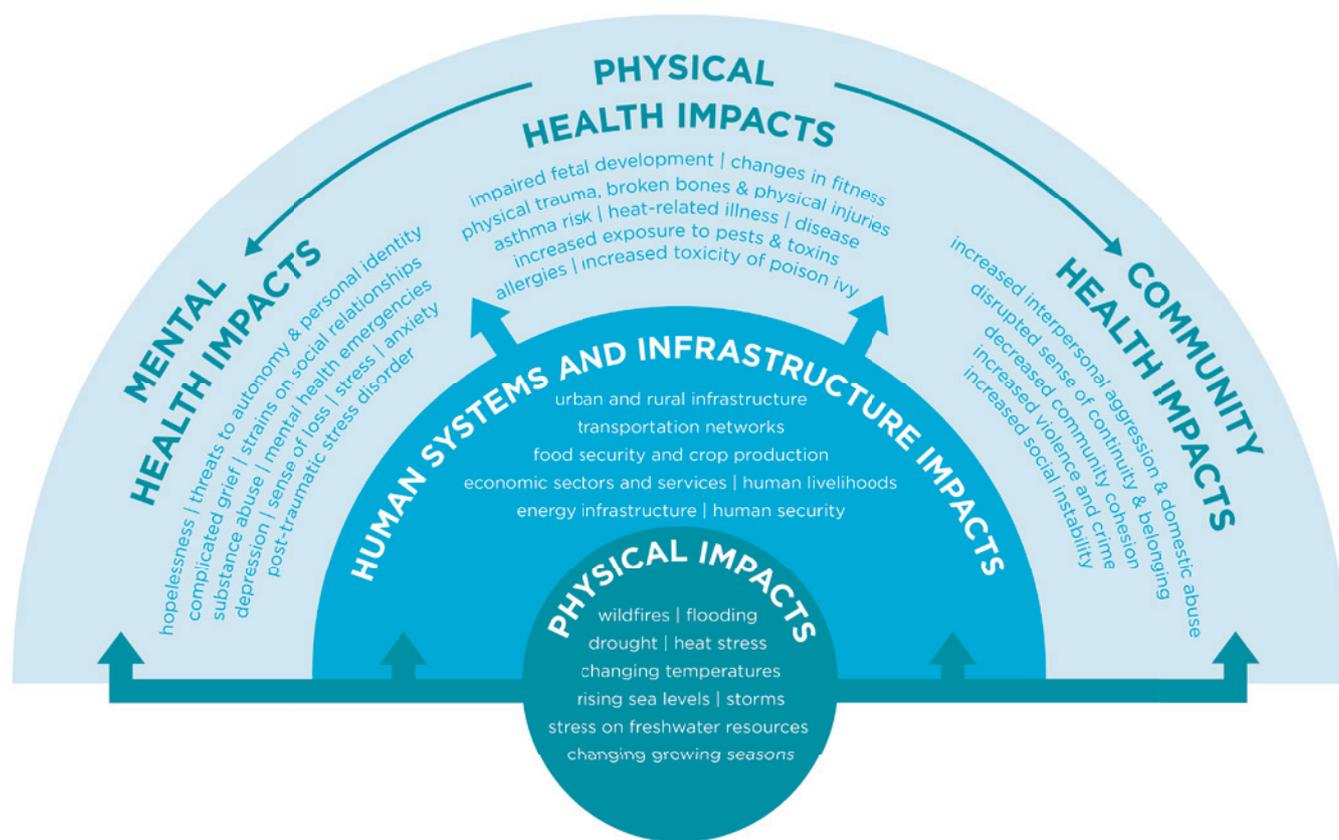
to adapt their livelihoods and lifestyles. Recent evidence suggests that psychological variables are also important<sup>84,85</sup>. As was true for perceptions and for behaviours driving climate change, there is a social component to this process. For example, farmers who discuss climate change and agricultural innovations with their peers are more likely to innovate in their own cultivation practices<sup>86</sup>. As many resources are managed collectively, and are therefore subject to conflicts over short-term individual interests versus long-term collective interests<sup>87</sup>, adaptation to climate change in some ways constitutes a social dilemma<sup>88</sup>. A wide body of psychological research describes precursors to and conditions for cooperative behaviour, such as trust and a sense of collective identity; this research is highly relevant here and can be applied to encourage effective adaptation, for example, by providing those who manage a shared resource with opportunities to meet as a group and discuss their shared concerns<sup>89</sup>.

Societal preparations for disasters can help to reduce negative impacts. However, it is critical to consider how individuals understand and act on information about risk, which, as described earlier, is heavily filtered through social psychological processes<sup>90</sup> and mental models<sup>28</sup>. People typically underestimate the likelihood of being affected by disaster events and therefore tend to under-rather than overreact<sup>91</sup>. Community preparedness and response to natural disasters can be improved by considering these processes in the design of education and messaging; for example, by accompanying risk information with information about the specific personal implications of the risk and about specific actions to address the risk<sup>92,93</sup>. The social and geographical context is also important. Strong place-based identities have been shown to impede successful adaptation, reducing willingness to learn new skills or to contemplate relocation<sup>94</sup>.

**Future research directions.** First, more research is needed on the impacts of climate change on human well-being and the possible impacts of environmental degradation on place attachment and identity. Second, compared with the focus on mitigation, psychological researchers have given relatively little attention to climate change adaptation responses. The possibilities for positive adaptations, and ways to encourage them, should be further explored<sup>95</sup>.

### Promoting interdisciplinary collaborations

Given the complexity of global climate change and the many factors involved, interdisciplinary collaboration is needed to research human interactions with climate. Psychological research can contribute important information concerning individual- and household-level factors in socio-ecological systems. Additionally, psychology has been called a 'hub' discipline: a field whose origins in physics, physiology and philosophy allow it to straddle the lines between social and natural science, and humanities. This may put it in a position to facilitate interdisciplinary collaborations more generally. Finally, the psychological perspective can also provide insight about organizational dynamics that can enhance the effective functioning of such multidisciplinary teams. To work effectively, these teams need to successfully confront challenges that may include defining the problem, explaining the relevant causal processes and describing a solution or outcome in ways that are acceptable and comprehensible across disciplinary boundaries. Psychologists have examined the challenges and successes of multidisciplinary research teams, and recommended processes to meet these challenges, including regular meetings of the whole team, with time built in for team members to become familiar with each others' disciplinary approaches and vocabulary, and a clear organization to facilitate the complex coordination involved<sup>96</sup>. Several recent papers<sup>7,97</sup> make suggestions for both organizations and researchers to improve their integration of social science and humanities into climate-change-related research, describing some



**Figure 4 | Mechanisms of climate change impact on human well-being.** Figure reproduced with permission from ref. 98, © 2014 APA and ecoAmerica.

of the translational activities and institutional changes that are necessary. This may also require broader changes in the ways in which scientific research is organized and evaluated.

**Future research directions.** First, researchers in organizational psychology and group processes should study the unique challenges faced by multidisciplinary teams trained in different methodologies, assumptions, and vocabularies to develop recommendations for effective practice. Second, researchers in educational psychology should evaluate the relative merits of emerging training structures such as multidisciplinary degree programmes and workshops compared with traditional monodisciplinary programmes.

### Conclusion

The psychological perspective is uniquely placed to understand individual- and household-level factors in socio-ecological systems, and can provide important input towards a multi-level approach integrating natural sciences, social sciences and the humanities. Researchers concerned with understanding and responding to climate change typically acknowledge that multiple disciplinary approaches are necessary, but do not always act on this recognition. It is time to develop effective ways to integrate psychological research into these efforts. To successfully communicate about risk, change behaviours that contribute to climate change, understand the impacts of climate change and facilitate adaptation, it is necessary to consider individual capabilities, cognitive processes, biases, values, beliefs, norms, identities and social relationships, and to integrate understanding at this level into broader understanding of human interactions with a changing climate.

Received 24 September 2014; accepted 24 March 2015;  
published online 24 June 2015

### References

1. National Research Council *Global Environmental Change: Understanding the Human Dimensions* (eds Stern, P. C., Young O. R. & Druckman, D.) (National Academies, 1992).
2. National Research Council *America's Climate Choices* (National Academies, 2011).
3. Dietz, T., Gardner, G., Gilligan, J. M., Stern, P. & Vandenberg, M. Household actions can provide a behavioural wedge to rapidly reduce US carbon emissions. *Proc. Natl Acad. Sci. USA* **106**, 18452–18456 (2009).
4. Bolderdijk, J. W. & Steg, L. in *Handbook of Research on Sustainable Consumption* (eds Thøgersen, J. & Reisch, L.) 328–342 (Edward Elgar, 2015).
5. Gardner, G. T. & Stern, P. C. *Environmental Problems and Human Behaviour* (Allyn & Bacon, 1996).
6. Swim, J. K., Geiger, A. N. & Zawadzki, S. J. Psychology and energy-use reduction policies. *Policy Insights Behav. Brain Sci.* **1**, 180–188 (2014).
7. Hackmann, H., Moser, S. C. & St. Clair, A. L. The social heart of global environmental change. *Nature Clim. Change* **4**, 653–655 (2014).
8. Sovacool, B. K. Energy studies need social science. *Nature* **511**, 529–530 (2014).
9. Stern, P. C. Psychological dimensions of global environmental change. *Annu. Rev. Psychol.* **43**, 269–302 (1992).
10. Swim, J. et al. Psychology's contributions to understanding and addressing global climate change. *Am. Psychol.* **66**, 241–250 (2011).
11. Clayton, S. & Myers, G. *Conservation Psychology: Understanding and Promoting Human Care for Nature* (Wiley-Blackwell, 2009).
12. Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N. & Upham, P. International trends in public perceptions of climate change over the past quarter century. *WIREs Clim. Change* **6**, 35–61 (2015).
13. Kahan, D. et al. The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Clim. Change* **2**, 732–735 (2012).
14. Gifford, R. The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *Am. Psychol.* **66**, 290–302 (2011).
15. Weber, E. U. & Stern, P. C. Public understanding of climate change in the United States. *Am. Psychol.* **66**, 315–328 (2011).
16. Rudman, L. A., McLean, M. C. & Bunzl, M. When truth is personally inconvenient, attitudes change: The impact of extreme weather on implicit support for green politicians and explicit climate-change beliefs. *Psychol. Sci.* **24**, 2290–2296 (2013).

17. Spence, A., Poortinga, W., Butler, C. & Pidgeon, N. F. Perceptions of climate change and willingness to save energy related to flood experience. *Nature Clim. Change* **1**, 46–49 (2011).
18. Whitmarsh, L. What's in a name? Commonalities and differences in public understanding of 'climate change' and 'global warming'. *Public Underst. Sci.* **18**, 401–420 (2009).
19. Howe, P. D. & Leiserowitz, A. R. Who remembers a hot summer or a cold winter? The asymmetric effect of beliefs about global warming on perceptions of local seasonal climate conditions in the U. S. *Glob. Environ. Change* **23**, 1488–1500 (2013).
20. Petty, R. E. & Cacioppo, J. T. *The Elaboration Likelihood Model of Persuasion* (Academic, 1986).
21. Fielding, K. S., Hornsey, M. J. & Swim, J. K. Developing a social psychology of climate change. *Eur. J. Soc. Psychol.* **44**, 413–420 (2014).
22. Guber, D. L. A cooling climate for change? Party polarization and the politics of global warming. *Am. Behav. Sci.* **57**, 93–115 (2013).
23. Poortinga, W., Spence, A., Whitmarsh, L., Capstick, S. & Pidgeon, N. Uncertain climate: An investigation into public skepticism about anthropogenic climate change. *Glob. Environ. Change* **21**, 1015–1024 (2011).
24. Costa, D. L. & Kahn, M. E. Do liberal home owners consume less energy? A test of the voluntary restraint hypothesis. *Econ. Lett.* **119**, 210–212 (2013).
25. Kahan, D. M., Jenkins-Smith, H. & Braman, D. Cultural cognition of scientific consensus. *J. Risk Res.* **14**, 147–174 (2010).
26. McCright, A., Xiao, C. & Dunlap, R. Political polarization on support for government spending on environmental protection in the USA, 1974–2012. *Soc. Sci. Res.* **48**, 251–260 (2013).
27. Painter, J. & Ashe, T. Cross-national comparison of the presence of climate scepticism in the print media in six countries, 2007–10. *Environ. Res. Lett.* **7**, 044005 (2012).
28. Stern, P. C. & Raimi, K. T. Simple mental models for informing climate choices. *Soc. Res.* (in the press).
29. Bolderdijk, J. W., Gorsira, M., Keizer, K. & Steg, L. Values determine the (in) effectiveness of informational interventions in promoting pro-environmental behaviour. *PLoS ONE* **8**, e83911 (2013).
30. Jang, S. M. Framing responsibility in climate change discourse: Ethnocentric attribution bias, perceived casus, and policy attitudes. *J. Environ. Psychol.* **36**, 27–36 (2013).
31. Kahneman, D. & Tversky, A. Judgment under uncertainty: Heuristics and biases. *Science* **185**, 1124–1131 (1974).
32. Brulle, R. J., Carmichael, J. & Jenkins, J. C. Shifting public opinion on climate change: An empirical assessment of factors influencing concern over climate change in the U.S., 2002–2010. *Clim. Change* **114**, 169–188 (2012).
33. Deryugina, T. How do people update? The effects of local weather fluctuations on beliefs about global warming. *Clim. Change* **118**, 397–416 (2013).
34. Slovic, P., Finucane, M. L., Peters, E. & MacGregor, D. G. Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality. *Risk Anal.* **24**, 311–322 (2004).
35. Lord, C. G., Ross, L. & Lepper, M. R. Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. *J. Pers. Soc. Psychol.* **37**, 2098–2109 (1979).
36. Corner, A., Whitmarsh, L. & Xenias, D. Uncertainty, skepticism and attitudes towards climate change: Biased assimilation and attitude polarisation. *Clim. Change* **114**, 463–478 (2012).
37. Kempton, W. How the public views climate change. *Environment* **39**, 12–21 (1997).
38. Bostrom, A., Böhm, G. & O'Connor, R. E. Tailoring climate change communication to audiences. *WIREs Clim. Change* **4**, 447–455 (2013).
39. Böhm, G. & Pfister, H.-R. Consequences, morality, and time in environmental risk evaluation. *J. Risk Res.* **8**, 461–479 (2005).
40. Gattig, A. & Hendrickx, L. Judgmental discounting and environmental risk perception. *J. Soc. Issues* **63**, 21–39 (2007).
41. Abrahamse, W. & Steg, L. How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings? *J. Econ. Psychol.* **30**, 711–720 (2009).
42. Gatersleben, B., Steg, L. & Vlek, C. Measurement and determinants of environmentally significant consumer behaviour. *Environ. Behav.* **34**, 335–362 (2002).
43. Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A. & Kalof, L. A value-belief-norm theory of support for social movements: The case of environmentalism. *Hum. Ecol. Rev.* **6**, 81–97 (1999).
44. Abrahamse, W. & Steg, L. Social influence approaches to encourage resource conservation: A meta-analysis. *Glob. Environ. Change* **23**, 1773–1785 (2013).
45. Van der Werf, E., Steg, L. & Keizer, K. The value of environmental self-identity: The relationship between biospheric values, environmental self-identity and environmental preferences, intentions and behaviour. *J. Environ. Psychol.* **34**, 55–63 (2013).
46. Kahneman, D. *Thinking Fast and Slow* (Farrer, Straus & Giroux, 2013).
47. Abrahamse, W., Steg, L., Vlek, C. & Rothengatter, T. A review of intervention studies aimed at household energy conservation. *J. Environ. Psychol.* **25**, 273–291 (2005).
48. Fischer, C. Feedback on household electricity consumption: A tool for saving energy? *Energ. Efficien.* **1**, 79–104 (2008).
49. Nolan, J. M., Schultz, P. W., Cialdini, R. B., Goldstein, N. J. & Griskevicius, V. Normative social influence is underdetected. *Pers. Soc. Psychol. B.* **34**, 913–923 (2008).
50. Cohen, M. A. & Vandenbergh, M. P. The potential role of carbon labeling in a green economy. *Energ. Econ.* **34**, S53–S63 (2012).
51. Shewmake, S., Cohen, M. A., Stern, P. C. & Vandenbergh, M. P. in *Handbook of Research on Sustainable Consumption* (eds Reisch, L. & Thøgersen J.) 285–299 (Edward Elgar, 2015).
52. Bolderdijk, J. W., Steg, L., Geller, E. S., Lehman, P. K. & Postmes, T. Comparing the effectiveness of monetary versus moral motives in environmental campaigning. *Nature Clim. Change* **3**, 413–416 (2013).
53. Hirst, E. & Brown, M. Closing the efficiency gap: Barriers to the efficient use of energy. *Resour. Conserv. Recy.* **3**, 267–281 (1990).
54. *Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency* (International Energy Agency, 2007); [http://www.iea.org/publications/freepublications/publication/mind\\_the\\_gap.pdf](http://www.iea.org/publications/freepublications/publication/mind_the_gap.pdf).
55. Stern, P. C. Blind spots in policy analysis: What economics doesn't say about energy use. *J. Policy Anal. Manag.* **5**, 200–227 (1986).
56. Stern, P. C., Gardner, G. T., Vandenbergh, M. P., Dietz, T. & Gilligan, J. Design principles for carbon emissions reduction programs. *Environ. Sci. Technol.* **44**, 4847–4848 (2010).
57. Vandenbergh, M. P., Stern, P. C., Gardner, G. T., Dietz, T. & Gilligan, J. Implementing the behavioural wedge. *Environ. Forum* **28**, 54–63 (2011).
58. Carrico, A. & Riemer, M. Motivating energy conservation in the workplace: An evaluation of the use of group-level feedback and peer education. *J. Environ. Psychol.* **31**, 1–13 (2011).
59. Evans, L. et al. Self-interest and pro-environmental behaviour. *Nature Clim. Change* **3**, 122–125 (2013).
60. Noppers, E., Keizer, K., Bolderdijk, J. W. & Steg, L. The adoption of sustainable innovations: Driven by symbolic and environmental motives. *Glob. Environ. Change* **25**, 52–62 (2014).
61. Devine-Wright, P., Wrapson, W., Henshaw, V. & Guy, S. Low carbon heating and older adults: Comfort, cosiness and glow. *Build. Res. Inf.* **42**, 288–299 (2014).
62. Dogan, E., Bolderdijk, J. W. & Steg, L. Making small numbers count: Environmental and financial feedback in promoting eco-driving behaviours. *J. Consum. Policy* **37**, 413–422 (2014).
63. Devine-Wright, P. Rethinking NIMBYism: The role of place attachment and place identity in explaining place protective action. *J. Community Appl. Soc.* **19**, 426–441 (2009).
64. Perlaviciute, G. & Steg, L. Contextual and psychological factors shaping evaluations and acceptability of energy alternatives: Integrated review and research agenda. *Renew. Sust. Energ. Rev.* **35**, 361–381 (2014).
65. Korpela, K. in *The Oxford Handbook of Environmental and Conservation Psychology* (ed Clayton, S.) 148–163 (Oxford Univ. Press, 2012).
66. Devine-Wright, P. & Howes, Y. Disruption to place attachment and the protection of restorative environments: A wind energy case study. *J. Environ. Psychol.* **30**, 271–280 (2010).
67. Devine-Wright, P. Explaining 'NIMBY' objections to a power line: The role of personal, place attachment and project-related factors. *Environ. Behav.* **45**, 761–781 (2013).
68. Steg, L., Dreijerink, L. & Abrahamse, W. Why are energy policies acceptable and effective? *Environ. Behav.* **38**, 92–111 (2006).
69. Eriksson, L., Garvill, J. & Nordlund, A. Acceptability of travel demand management measures: The importance of problem awareness, personal norm, freedom, and fairness. *J. Environ. Psychol.* **26**, 15–26 (2006).
70. Schuitema, G., Steg, L. & Rothengatter, J. A. Relationship between the acceptability, personal outcome expectations and the expected effects of transport pricing policies. *J. Environ. Psychol.* **30**, 587–593 (2010).
71. Dreyer, S. & Walker, I. Acceptance and support of the Australian carbon policy. *Soc. Justice Res.* **26**, 323–362 (2013).
72. Schuitema, G., Steg, L. & Van Kruijning, M. When are transport policies fair and acceptable? The role of six fairness principles. *Soc. Justice Res.* **24**, 66–84 (2011).
73. Doherty, T. & Clayton, S. The psychological impacts of global climate change. *Am. Psychol.* **66**, 265–276 (2011).
74. Weissbecker, I. (ed) *Climate Change and Human Well-Being: Global Challenges and Opportunities* (Springer, 2011).
75. IPCC *Climate Change 2013: The Physical Science Basis* (eds Stocker, T. et al.) (Cambridge Univ. Press, 2013).

76. National Research Council *Climate and Social Stress: Implications for Security Analysis* (eds Steinbruner, J. D., Stern, P. C. & Husbands, J. L.) (National Academies, 2013).
77. Galea, S., Nandi, A. & Vlahov, D. The epidemiology of post-traumatic stress disorder after disasters. *Epidemiol. Rev.* **27**, 78–91 (2005).
78. Norris, F. H. *et al.* 60,000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981–2001. *Psychiatry* **65**, 207–239 (2002).
79. Agnew, R. Dire forecast: A theoretical model of the impact of climate change on crime. *Theor. Criminol.* **16**, 21–42 (2012).
80. Hsiang, S., Burke, M. & Miguel, E. Quantifying the influence of climate on human conflict. *Science* **341**, 1235367 (2013).
81. Warner, K. Global environmental change and migration: Governance challenges. *Glob. Environ. Change* **20**, 402–413 (2010).
82. Speller, G., Lyons, E. & Twigger-Ross, C. A community in transition: The relationship between spatial change and identity. *Soc. Psychol. Rev.* **4**, 39–58 (2002).
83. Agyeman, J., Devine-Wright, P. & Prange, J. ‘Close to the edge, down by the river?’ Joining up managed retreat and place attachment in a climate changed world. *Environ. Plann. A* **41**, 509–513 (2009).
84. Grothmann, T. & Patt, A. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Glob. Environ. Change* **15**, 199–213 (2005).
85. Bockarjova, M. & Steg, L. Can Protection Motivation Theory predict pro-environmental behaviour? Explaining the adoption of electric vehicles in the Netherlands. *Glob. Environ. Change* **28**, 276–288 (2014).
86. Esham, M. & Garforth, C. Agricultural adaptation to climate change: Insights from a farming community in Sri Lanka. *Mitig. Adapt. Strat. Glob. Change* **18**, 535–549 (2012).
87. Ostrom, E. A general framework for analyzing sustainability of social-ecological systems. *Science* **325**, 419–22 (2009).
88. Van Vugt, M. Averting the tragedy of the commons: Using social psychological science to protect the environment. *Curr. Dir. Psychol. Sci.* **18**, 169–173 (2009).
89. Penner, L. A., Dovidio, J. F., Piliavin, J. A. & Schroeder, D. A. Prosocial behaviour: Multilevel perspectives. *Annu. Rev. Psychol.* **56**, 365–392 (2005).
90. Dash, N. & Gladwin, H. Evacuation decision making and behavioural responses: Individual and household. *Natural Hazards Rev.* **8**, 69–77 (2007).
91. Kunreuther, H. Mitigating disaster losses through insurance. *J. Risk Uncertainty* **12**, 171–187 (1996).
92. De Dominicis, S. *et al.* Vested interest and environmental risk communication: Improving willingness to cope with impending disasters. *J. Appl. Soc. Psychol.* **44**, 364–374 (2014).
93. Rogers, M., Curtis, A. & Mazur, N. The influence of cognitive processes on rural landholder responses to climate change. *J. Environ. Manage.* **111**, 258–266 (2012).
94. Marshall, N. A., Park, S. E., Adger, N. E., Brown, K. & Howden, S. M. Transformational capacity and the influence of place and identity. *Environ. Res. Lett.* **7**, 034032 (2012).
95. De Young, R. Some behavioural aspects of energy descent: How a biophysical psychology might help people transition through the lean times ahead. *Front. Psychol.* **5**, 1255 (2014).
96. Schoot Uiterkamp, A. & Vlek, C. Practice and outcomes of multidisciplinary research for environmental sustainability. *J. Soc. Issues* **63**, 175–197 (2007).
97. Weaver, C. P. *et al.* From global change science to action with social sciences. *Nature Clim. Change* **4**, 656–659 (2014).
98. Clayton, S., Manning, C. M. & Hodge, C. *Beyond Storms & Droughts: The Psychological Impacts of Climate Change* (American Psychological Association and ecoAmerica, 2014); <http://ecoamerica.org/research/#PsychImpacts>.

### Acknowledgements

The authors thank J. Taylor of the Wildlife and Environment Society of South Africa and C. Werner of the University of Utah for their contributions to the workshop from which this paper developed. We also acknowledge the support of the National Socio-Environmental Synthesis Center (NSF award DBI-1052875).

### Author contributions

All authors contributed to the writing of this paper.

### Additional information

Reprints and permissions information is available online at [www.nature.com/reprints](http://www.nature.com/reprints). Correspondence should be addressed to S.C.

### Competing financial interests

The authors declare no competing financial interests.