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Emotions, worry, efficacy, and climate change–related sustainability behaviors among a representative sample of Texas and Florida residents

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Abstract
Uptake and support of sustainable technologies that decrease greenhouse gas emissions are critical to mitigating climate change. Engagement in individual (e.g., eating less meat, electric car use) and collective (e.g., petition signing, donating money to environmental causes) sustainability behaviors may correlate with psychological factors including emotions, worry about climate change and natural hazards, and response efficacy. However, little research has explored these relationships in representative samples at high risk for climate-related hazard exposures (e.g., hurricanes, heatwaves, flooding). We assessed climate change-related sustainability behaviors in an ongoing, probability-based representative survey of 1479 Texas and Florida residents repeatedly exposed to climate-related hazards including hurricanes, heatwaves, flooding, and tornadoes. Controlling for demographics, behavior-related positive and negative emotions correlated with engagement in performing a greater number of collective-level sustainability behaviors (positive emotions: IRR = 2.06, $p < .001$; negative emotions: IRR = 1.46, $p = .030$). However, negative emotions were mediated by natural hazard worry, which in turn was mediated by climate change worry. Positive emotions were mediated by response efficacy. Individual-level sustainability behaviors were associated with positive emotions (IRR = 1.18, $p < .001$), which were again mediated by response efficacy. In adjusted analyses unpacking the relationship between discrete emotions and sustainability behaviors, hope was associated with individual- and collective-level sustainability behaviors (all $ps < .05$). Results suggest general climate change worry may be adaptive and that feelings of hope, relative to other emotions (both positive and negative), may help encourage sustainability behaviors that address climate change. Scalable interventions should explore leveraging these psychological experiences to promote uptake of sustainable technology-related behaviors more broadly.

Keywords Climate change · Emotions · Worry · Mitigation behaviors · Pro-environmental behaviors

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1 Introduction

Mitigating the existential threat of climate change necessitates engagement in activities that increase the adoption of sustainability practices and technologies (i.e., meeting human needs without compromising ecosystem health; Morelli 2021). Yet sustainability technologies that lower pollution (including greenhouse gases), increase energy efficiency, and spur demand for eco-friendly innovation (Ebrahim 2020) can only help mitigate climate change if individuals personally adopt them and support policies encouraging their broad implementation. If not, such innovations in sustainable technology will do little to impact the escalating climate crisis.

Uptake and support of sustainable technologies happen at the individual- (Bouman et al. 2020) and collective-level (Nielsen et al. 2021). Individual-level sustainability behaviors include lifestyle choices and household decisions associated with decreased greenhouse gas emissions, including lowering meat consumption (Poore and Nemecek 2018) and conserving energy (Bouman et al. 2020; Capstick et al. 2014). The impact of these actions on reducing greenhouse gas emissions may be profound (Nielsen et al. 2021). For example, a relatively modest modification to the typical United Kingdom (U.K.) diet that reduces animal product consumption and increases consumption of fruits, vegetables, and cereals could decrease U.K. greenhouse gas emissions by 40% (Green et al. 2015). Collective-level behaviors target community and/or system-level changes in practice or policy that increase broad uptake of sustainable technology, in turn reducing greenhouse gas emissions widely. These actions include working with pro-environmental organizations, signing a petition, donating money to environmental protection groups, protesting, and voting for pro-environmental political candidates (Latkin et al. 2022). Although it is difficult to quantify the magnitude of such efforts, resulting policies may be transformative if legislation is strong and implemented globally (Eskander and Fankhauser 2020). Yet governments may not enact such practices and policies without pressure from citizens and groups (Roser-Renouf et al. 2014). Meaningful reductions in greenhouse gas emissions require individual- and collective-level behaviors to propel societal transformation towards greater sustainability (Bamberg et al. 2018). It is critical to understand the psychological antecedents guiding engagement in these behaviors (Bamberg et al. 2018; Schwartz et al. 2022).

A recent nationally representative survey found the majority (55%) of United States (U.S.) adults are alarmed or concerned about climate change (Leiserowitz et al. 2021a). Yet, while many individuals report willingness to act to reduce climate change impacts (Bell et al. 2021), performance of many sustainability behaviors is relatively low (Leiserowitz et al. 2021a). For example, in a nationally representative sample of U.S. adults, a majority (69%) who indicated global warming was an important issue also reported voting for candidates who support climate change mitigation policies; yet only a minority engaged in other collective behaviors like donating money (29.8%), signing a petition (32.3%), or contacting government officials (11.9%) (Latkin et al. 2022). Demographic (e.g., gender, political orientation), external (e.g., economic, social, cultural), and internal (e.g., knowledge, motivation) factors can facilitate or dampen the performance of sustainability behaviors (Kollmuss and Agyeman 2010; Li et al. 2019), with psychological factors exhibiting particularly strong effects on behavior (Li et al. 2019). For example, anticipatory hope (Geiger et al. 2021) and perseverative cognition like worry (Bouman et al. 2020) positively correlate, and boredom negatively correlates (Geiger et al. 2021), with performance of sustainability behaviors.

The perceived effectiveness of performing sustainability behaviors (i.e., response efficacy) that mitigate climate change's threat may also correlate with the frequency of performing those behaviors (Bradley et al. 2020). Given the disconnect between the often-stated importance of climate change and the performance of sustainability behaviors, understanding psychological factors that encourage or dampen engagement is important for meeting critical targets for greenhouse gas emissions reduction, a key component of halting climate change (Nielsen et al. 2021). Yet little research with representative samples, particularly in communities at high risk for climate-related impacts, have been conducted on the interrelationships between emotions related to performing sustainability behaviors, perseverative cognition (i.e., worry) about general climate change and related natural hazards, response efficacy, and performance of climate change-mitigating sustainability behaviors.

As climate change escalates and communities experience more acute impacts through natural hazards and climate change-related disasters (e.g., catastrophic hurricanes, wildfires, flooding, heatwaves), individuals may respond by performing more sustainability behaviors to address these threats. Moreover, there may be a "spillover" effect between general climate change worry (e.g., worry about the existential threat of climate change) and worry about climate change's direct impacts through acute (e.g., hurricanes, wildfires) and chronic (e.g., nuisance flooding) natural hazards.

In this report, we leverage representative samples of residents from Florida and Texas, two U.S. Gulf Coast states located in a region at elevated risk for a number of specific climate-related impacts (Sobel et al. 2016) including catastrophic hurricanes (i.e., category 3 or higher), flooding, heatwaves, and tornadoes. We explored relationships between general climate change worry, specific worry about natural hazards, performance of sustainability behaviors that address climate change, and emotions and response efficacy regarding those behaviors. This provides an important opportunity to contextualize sustainability behaviors within exposure to ecologically valid climate change-related hazards.

1.1 Emotions and climate change–related sustainability behaviors

Emotions are powerful motivators of behaviors. This likely occurs through a reciprocal feedback system: performing behaviors results in emotional states and subsequent retrospective appraisal that informs subsequent behavior (Baumeister et al 2007). For example, an individual may recycle, which triggers a feeling of hope or other positive emotion that then encourages future recycling. Emotions include experiential (e.g., "feeling") and cognitive components (Solomon 2000) and have robust associations with judgments, choices, and behaviors (Loewenstein and Lerner 2003). The intensity of emotions may decrease psychological distance (Van Boven et al. 2010), potentially increasing the relevance of the climate crisis and motivating positive action for change (Chu and Yang 2019, 2020; Maiella et al. 2020). Although a feedback system perspective may appear most relevant to experiencing and anticipating positive emotions and then performing behaviors associated with those positive states (Baumeister et al 2007), research also demonstrates a reciprocal relationship between negative states and performing behaviors. For example, threat exposure, psychological distress, worry, and behaviors such as consuming media (a type of information seeking) during a collective trauma exhibit reciprocal relationships (Thompson et al. 2019). Yet, it is unclear whether positive or negative emotions have a stronger relationship with climate change-related sustainability behaviors (Brosch 2021). Furthermore, which specific emotions are the primary correlates of sustainability behaviors have not been firmly established (Salama and Aboukoura 2017).

The "broaden and build" theory of positive emotion suggests subsets of positive emotions, including joy, interest, and contentment broaden "action repertoires" and support adaptive psychological resources (Fredrickson 1998), which may include sustainability behaviors. For example, anticipatory and experienced positive emotions have been associated with pro-environmental behaviors (Brosch 2021; Schneider et al. 2021), likely facilitated by increased motivation, perseverance, and prosocial behaviors often associated with positive emotional states (Schneider et al. 2021). More specifically, self-reported feelings of hope were associated with interest in climate protection in a sample of undergraduate students (Chadwick 2015), support for collective climate change action (e.g., supporting a carbon tax) in a sample of Australian adults recruited through social media (Bury et al. 2020), and sustainability behaviors (e.g., recycling, walking/bicycling to work, conserving water, conserving energy) in a sample of young people in Sweden (Ojala 2012). In a large, geographically diverse sample of U.S. adults recruited from information science learning centers (e.g., zoos), feelings of hope and boredom were positively and negatively associated with intentions to act on climate change, respectively (Geiger et al. 2021). In an experimental study using MTurk workers, anticipated pride, contrasted with anticipated guilt, prior to making an environmental decision was associated with pro-environmental behavioral intentions (Schneider et al. 2017).

1.2 Worry about the climate crisis and related natural hazards

Worry is a complex emotional experience related to fear and anxiety, having both cognitive and emotional components (Segerstrom et al. 2003). Worry involves repetitive thinking about future events, specifically unpleasant stimuli (Sweeny and Dooley 2017), with more cognitive components than general anxiety (Ojala et al. 2021). Repetitive thought processes and perseverative cognition, like worry, correlate with reports of depression, anxiety, and impaired physical health (Watkins 2008). Research with non-representative samples demonstrates that climate change–related worry is common (Gregersen et al. 2020). Yet while such worry may have detrimental effects (Doherty and Clayton 2011; Ojala et al. 2021; Panu 2020), it may also motivate action (Ojala et al. 2021). Indeed, non-clinical worry may facilitate constructive problem solving in response to risk (Ojala et al. 2021), positive coping in response to threat (MacLeod et al. 1991; Sweeny and Dooley 2017), adaptive preparation and anticipatory planning, and health-protective behaviors (Watkins 2008). Worry may orient one towards threat-mitigation opportunities that promote desirable outcomes (Sweeny and Dooley 2017). For example, in a sample of 422 Swedish young people, worry was associated with recycling (Ojala 2008); data from a large sample of Europeans (eight countries, $N = 44{,}387$) demonstrated that climate change worry was associated with energy curtailment and energy efficiency behaviors. Yet importantly, worry may also be a part of a feedback loop between behavior and distress responses: as mentioned previously, in a longitudinal, representative sample of 4165 U.S. residents, media exposure to a threat was associated with distress responses, worry about future events, subsequent media exposure, and subsequent distress (Thompson et al. 2019). Despite conceptual work (Baumeister et al. 2007), these processes have not been adequately studied in ecologically valid contexts with respect to sustainability behaviors, particularly in representative samples repeatedly exposed to climate hazards.

1.3 Perceived efficacy of climate change–related sustainability behaviors

Despite widespread concern about the climate crisis and agreement that mitigation actions are necessary (Bell et al. 2021), many people do not engage in sustainability behaviors. This disconnect may result from low response efficacy that these actions will result in meaningful mitigation. For example, approximately 80% of individuals from 16 advanced economies (i.e., "industrialized nations" with high gross domestic product per capita), including the U.S., Germany, Singapore, Greece, Sweden, and Taiwan, report willingness to make changes to how they live and work to reduce the negative impacts of the climate crisis; concurrently, individuals tend to have low confidence that collective-level climate change–related mitigation behaviors will effectively mitigate the threat of climate change (Bell et al. 2021).

Self-efficacy involves the belief that one is capable of acting to improve one's welfare (Bandura 1977); response efficacy is the belief those actions will effectively reduce a threat (Witte 1992). In general, perceptions of efficacy are strongly associated with initiating and maintaining adaptive behaviors (Strecher et al 1986). Prior analyses demonstrated that efficacy was associated with preparation for hurricanes (Garfin et al. 2023), which are projected to intensify because of climate change (Bloemendaal et al. 2022; Emanuel 2020). In the context of climate change behaviors specifically, perceptions of collective efficacy related to the ability to change the system (Roser-Renouf et al. 2014) and individual efficacy (the extent to which one can personally mitigate climate change) (Hornsey et al. 2021) are important correlates of climate change-related sustainability behaviors. Indeed, meta-analytic findings indicate efficacy is one of the strongest correlates of climate change adaptation behaviors (van Valkengoed and Steg 2019). Yet, perhaps due to the enormous challenge of addressing climate change, individuals may feel their actions may not help reduce threat (van der Linden et al. 2015). They may also feel they lack the necessary skills to effectively perform such actions: in a representative sample of U.S. adults, among those who reported climate change was a pressing issue, the most common reason for not engaging in collective actions was the perception that others were better at performing them (Latkin et al. 2022). Importantly, that finding was behavior specific: feeling that others performed actions better negatively correlated with volunteering (which may be viewed as requiring more skill) but not petition signing (a low-skill behavior). Thus, efficacy may depend on type of sustainability behavior targeted.

1.4 The present study

Here, we explored the relative contributions of emotions, worry, and efficacy on predicting engagement in individual- and collective-level sustainability behaviors. As a case study, we utilized data from a probability-based representative sample of residents from Texas and Florida, two states that have experienced escalating climate change-related threats in recent years, including several acute disasters: catastrophic hurricanes (i.e., category 3 or higher), flooding, extreme heatwaves, and tornadoes. Prior analyses demonstrated exposure to climate change–related disasters (e.g., lost property due to hurricane, hurricane evacuation experience) within the sample was substantial (Garfin et al. 2022). We asked several research questions:

1. Are there key demographic differences in performance of individual- and collective-level sustainability behaviors?

2. Do positive or negative emotions about performing those behaviors (i.e., behavioral emotions) have a stronger relationship with engagement in individual- and collective-level sustainability behaviors?
3. Do discrete behavioral emotions (e.g., hope, confidence, powerlessness, lacking control) and worry (both general climate change worry and specific natural hazard worry) predict performance of individual- and collective-level sustainability behaviors?
4. Controlling for the relationship between behavioral emotions, demographics, and sustainability behaviors, does response efficacy exhibit independent associations with performance of individual- and collective-level sustainability behaviors?
5. Are there interaction (i.e., moderation) effects between behavioral emotions, worry, and response efficacy on performance of individual- and collective-level sustainability behaviors?

2 Method

2.1 Participants

Participants were drawn from the GfK KnowledgePanel. GfK (now Ipsos) uses Address Based Sampling (ABS) to randomly recruit panelists using probability-based sampling methods: the panel is designed to be representative of the U.S. ABS uses the Delivery Sequence File (DSF) of the U.S. Postal Service, which improves population coverage relative to traditional random-digit-dialing methods and enables recruitment of harder-to-reach individuals such as younger people or minority groups. Households without an Internet connection are provided a web-enabled device and free Internet services. Once household members are recruited for the panel and assigned to a study sample, they are notified electronically of the opportunity to participate. They can then take the survey through their email link or by visiting their online member page.

Data are from a larger, longitudinal study of responses to hurricanes on the Gulf Coast. The first wave of data was collected between 6 p.m. 9/8/2017 and 6 a.m. 9/11/2017; all 5940 eligible KnowledgePanel panelists living in Florida or Texas were invited to participate; 2774 completed the survey (46.7% response rate) during the 60 h of data collection. The data presented herein are from the fifth wave of data collection, which occurred between 12/22/2021 and 1/11/2022. Of 1766 eligible panelists recruited to participate in wave 5 (i.e., those who had completed prior waves of data and had agreed to be contacted for future surveys), 1479 completed the survey (83.7% response rate).

2.2 Measures

2.2.1 Sustainability behaviors

Individual-level sustainability behaviors Participants reported which of the following they had engaged in during the past week: (1) "Used public transportation, biked, or walked to work instead of driving"; (2) "used energy-efficient lightbulbs such as CFLs or LEDs"; (3) "recycled"; (4) "taken shorter showers"; (5) "driven a hybrid or electric vehicle"; (6) "reduced red meat consumption"; (7) "ate a more plant-based diet"; (8) "reduced food waste"; (9) "composted waste"; (10) "checked the air in your tires to ensure

fuel efficiency"; (11) "used a smart thermostat"; and (12) "installed or used low-flow shower heads or faucets". Items were derived from prior research (Mascatelli et al. 2021). Responses were summed.

Collective-level sustainability behaviors Participants indicated which of the following they had performed in the past year: (1) "Worked with community members to help people prepare for hurricanes or other natural disasters"; (2) "worked with community members to create green spaces (e.g., plant trees, restore habitat) in my community"; (3) "signed a petition in support of action to help the environment"; (4) "signed a petition in support of action on climate change"; (5) "made a donation in support of action on climate change". Items were based on prior research (Roser-Renouf et al. 2014). Responses were summed.

2.2.2 Worry

Natural hazard worry Respondents were asked "How much do you worry about the following personally affecting you or someone in your family in the future?" and "How often in the past week have you had fears about the possibility of the following affecting the community where you live?" with respect to six climate-related hazards: major flooding, nuisance flooding, hurricanes, heatwaves, tornadoes, and sea level rise (12 items total). Response options were 1 (*never*) to 5 (*all the time*). Reliability was excellent $\alpha = 0.90$. Consistent with prior research, items were combined to measure worry as perseverative cognition (e.g., ruminative or repeated thoughts about the future) rather than worry and fear as distinct states (Williams et al. 2022). Items were derived from prior work (Holman et al. 2008; Sweeting et al. 2020; Williams et al. 2022).

General climate change worry Respondents were asked how much they worried about climate change "personally affecting you or someone in your family in the future?" and how often in the past week they had fears about climate change "affecting the community where you live?" Response options were 1 (*never*) to 5 (*all the time*). Reliability was excellent $\alpha = 0.90$. Items were derived from prior research (Holman et al. 2008; Sweeting et al. 2020; Williams et al. 2022).

2.2.3 Sustainability-related behavioral emotions

Respondents were asked, "When you reflect on your ability to take action to address climate change, do you feel": (1) hopeful, (2) confident, (3) optimistic, (4) helpless, (5) powerless, (6) lacking control, (7) indifferent, (8) on edge, (9) uneasy, and (10) nervous. Respondents reported on each of the 10 emotions, with response options 1 (*definitely do not feel this*) to 4 (*definitely feel this*). Items were also grouped into composites of positive (i.e., hopeful, confident, optimistic) and negative (i.e., helpless, powerless, lacking control, on edge, uneasy, nervous) behavioral emotions. In supplemental analyses, items were combined into a single measure of behavioral emotion intensity. Items were derived from prior work, which identified these behavioral emotions distinct from, although related to, self-efficacy (Geiger et al. 2021).

2.2.4 Response efficacy

Individual-level response efficacy Response efficacy regarding individual-level sustainability behaviors was assessed by asking: "Of the actions above that you do, how much will they help reduce the impacts of climate change?" Response options were 1 (*not at all*) to 5 (*completely*). Given the low number of respondents ($n = 12$) in the highest group, responses 4 and 5 were combined.

Collective-level response efficacy Respondents were asked "Of the actions above that you do, how much will they help reduce the impacts of climate change?" Response options were 1 (*not at all*) to 5 (*completely*). Given the low number of respondents ($n = 10$) in the highest group, responses 4 and 5 were combined.

All study specific measures are included in Supplemental Materials I.

2.3 Analytic strategy

First, descriptive statistics were calculated for all key study variables and a correlation matrix was constructed. Second, two multiple Poisson regression analyses (appropriate for count data) examined demographic indicators (race/ethnicity, gender, income, age, education [bachelor's degree or higher = 1, less than a bachelor's degree = 0] and political party identification [a 7-item scale ranging from 1 = strong Republican to 7 = strong Democrat]) as independent variables with the dependent variables of (1) individual-level sustainability behaviors and (2) collective-level sustainability behaviors. Third, for each dependent variable (individual- and collective-level sustainability behaviors), a series of Poisson regressions examined each's association with discrete emotions (hopeful, confident, optimistic, helpless, powerless, lacking control, indifferent, on edge, uneasy, and nervous) related to performing sustainability behaviors. Variables were added using a hierarchical variable entry strategy in conceptually meaningful blocks to illustrate their relative contribution. Non-significant variables were retained in subsequent models in accordance with our preregistration plan. Variables were added as follows: *model 1* included demographics and behavioral emotions, *model 2* added natural hazard worry, *model 3* added general climate change worry, and *model 4* added response efficacy of sustainability behaviors. Fourth, using an identical, four-model approach, a series of Poisson regressions examined the association between (1) individual- and (2) collective-level sustainability behaviors and composite positive and negative behavioral emotions. Interaction terms between positive emotions and self-efficacy and negative emotions and worry were calculated and examined in post-hoc exploratory analyses. In supplemental analyses, positive and negative behavioral emotions were combined into one measure of behavioral emotion intensity. Analyses were preregistered on the Open Science Framework (https://www.https://doi.org/10.17605/OSF.IO/UDG9A). Procedures were approved by the Institutional Review Boards at Stanford University and the University of California, Irvine.

All descriptive and inferential statistics were weighted using study-specific post-stratification weights, which account for the initial panel sampling design, probability of panel selection, non-response, and attrition over the course of the parent cohort study. These weights were calculated to adjust the final study sample to the demographic compositions of Florida and Texas for adults 18 and older. At each wave, sample weights accounted for attrition and adjusted the final sample to target benchmarks, enabling population-based

inferences over time and at each wave of data collection. Weighting benchmarks were based on the U.S. Census Bureau's Current Population Survey (March 2021 update), and were calculated using the following demographic cells: gender (male, female), age (18–29, 30–44, 45–59, 60+), race/ethnicity (White/Non-Hispanic, Black/Non-Hispanic, Other/Non-Hispanic, Hispanic, 2+Races/Non-Hispanic), household income (under $25,000, $25,000–$49,999, $50,000–$74,999, $75,000–$99,999, $100,000–$149,999, $150,000 and over), metro/non-metro areas, and education (less than high school/high school, some college, bachelor's or higher).

3 Results

3.1 Description of the sample

The sample was 53% ($n=787$) female; mean age was 51.53 (SD = 16.31). Racial/ethnic identity was reported as follows: White person (55.01%, $n=814$), Black, non-Hispanic person (12.06%, $n=178$), other or mixed (2 or more) identified person (5.32%, $n=79$), and Hispanic person (27.60%, $n=408$). Income was reported as less than $10,000 (5%, $n=74$), $10,000–$24,999 (10.51%, $n=155$) $25,000–$49,999 (20.87%, $n=309$), $50,00–$74,999 (18.74%, $n=277$), $75,000–$99,999 (13.81%, $n=204$), $100,000–$149,000 (10.82%, $n=160$), $150,000–$249,999 (5.98%, $n=88$), and $250,000+ (14.26%, $n=211$). Of the sample, 30.72% ($n=454$) reported obtaining a bachelor's degree or higher (i.e., college educated). The sample was politically diverse, identifying as the following: 17.88% ($n=265$) strong Republican, 13.44% ($n=199$) not strong Republican, 14.17% ($n=210$) leans Republican, 6.52% ($n=96$) undecided, 19.29% ($n=285$) leans Democrat, 10.70% ($n=158$) not strong Democrat, and 16.78% ($n=248$) strong Democrat.

3.2 Descriptive statistics of sustainability behaviors, emotions, worry, and efficacy

Overall, many people participated in at least some individual-level sustainability behaviors ($M=3.33$, SD = 2.30), with 91.30% ($n=1350$) reporting engaging in at least one behavior. The most common behaviors were recycling (67.07%), using energy-efficient lightbulbs (60.71%), taking shorter showers (32.29%), and reducing food waste (33.31%); see Table 1. A substantial minority also reported checking the air in car tires to ensure fuel efficiency (26.17%) and reducing meat consumption (25.74%). Participation in collective-level sustainability behavior was lower (M = 0.28, SD = 0.77); a sizable majority (83.12% $n=1229$) reported no collective-level sustainability behaviors. The most common behaviors were signing a petition to help the environment (8.31%) or climate change specifically (6.62%) or donating to an environmental cause (7.00%). See Fig. 1a for distributions of unweighted count responses for both individual- and collective-level sustainability behaviors.

Efficacy of these behaviors to reduce the impacts of climate change (i.e., response efficacy) was relatively low (see Fig. 1b). The mean response efficacy of individual-level sustainability behaviors was 2.21 (SD = 0.91), slightly above "just a little". The mean response efficacy of collective-level sustainability behaviors was 1.84 (SD = 0.96), slightly lower than "just a little". Multiple regression analyses indicated that individual-level response efficacy was positively associated with self-reported female gender ($b=0.21$, 95% CI, 0.06, 0.35, $p=0.006$), income ($b=0.06$, 95% CI, 0.02, 0.10, $p=0.005$), and stronger identification as

Table 1 Descriptive statistics of sustainability behaviors performed ($N = 1479$)

Behavior	%	*n*
Individual-level sustainability behaviors taken in response to environmental change		
Used public transportation, biked or walked to work instead of driving	6.93	103
Used energy-efficient lightbulbs such as CFLs or LEDs	60.71	898
Recycled	67.07	992
Taken shorter showers	32.29	478
Driven a hybrid or electric vehicle	6.67	99
Reduced meat consumption	25.74	381
Ate a more plant-based diet	16.79	248
Reduced food waste	33.31	493
Composted waste	10.71	158
Checked the air in your tires to ensure fuel efficiency	26.17	387
Used a smart thermostat	23.94	354
Installed or used low-flow shower heads or faucets	16.46	243
Collective-level sustainability behaviors taken in response to environmental change		
Worked with community members to help people prepare for hurricanes or other natural disasters	3.10	46
Worked with community members to create green spaces (e.g., plant trees, restore habitat) in my community	3.08	45
Signed a petition in support of action to help the environment	8.31	123
Signed a petition in support of action on climate change	6.62	98
Made a donation in support of action on climate change	7.00	104

Weighted Ns and %s presented

a Democrat compared to a Republican ($b = 0.11$, 95% CI, 0.07, 0.15, $p < 0.001$). Collective-level response efficacy was positively associated with identifying as Hispanic compared to White ($b = 0.22$, 95% CI, 0.01, 0.43, $p = 0.041$), female gender ($b = 0.17$, 95% CI, 0.01, 0.33, $p = 0.032$), achieving a bachelor's degree or higher ($b = 0.18$, 95% CI, 0.01, 0.34, $p = 0.039$), and stronger identification as a Democrat compared to a Republican ($b = 0.11$, 95% CI, 0.07, 0.14, $p < 0.001$). See Supplemental Table 1 for full results.

Table 2 presents descriptive statistics of worry and composite behavioral emotions regarding one's ability to act to address climate change. Mean natural hazard worry was, on average, below the scale midpoint ($M = 1.81$, SD = 0.69). Mean general climate change worry was slightly higher ($M = 2.19$, SD = 1.16). Natural hazard worry was positively associated with identifying as Hispanic compared to White ($b = 0.42$, 95% CI, 0.25, 0.59, $p < 0.001$), female gender ($b = 0.17$, 95% CI, 0.05, 0.29, $p = 0.006$), and identifying more strongly as a Democrat compared to a Republican ($b = 0.04$, 95% CI, 0.005, 0.07, $p = 0.025$). General climate change worry was associated with identifying as Hispanic compared to White ($b = 0.47$, 95% CI, 0.23, 0.71, $p < 0.001$) and identifying more strongly as a Democrat compared to a Republican ($b = 0.23$, 95% CI, 0.18, 0.27, $p < 0.001$). See Supplemental Table 2 for full models of correlates of natural hazard worry and general climate change worry. Emotional responses to performing sustainability behaviors (i.e., behavioral emotions) were low; mean responses for the majority of emotions hovered below the midpoint of 2.5 (between "do not feel like this" and "feel this"). Demographic correlates of positive emotions, negative emotions, and discrete emotions are presented in Supplemental Tables 3–6.

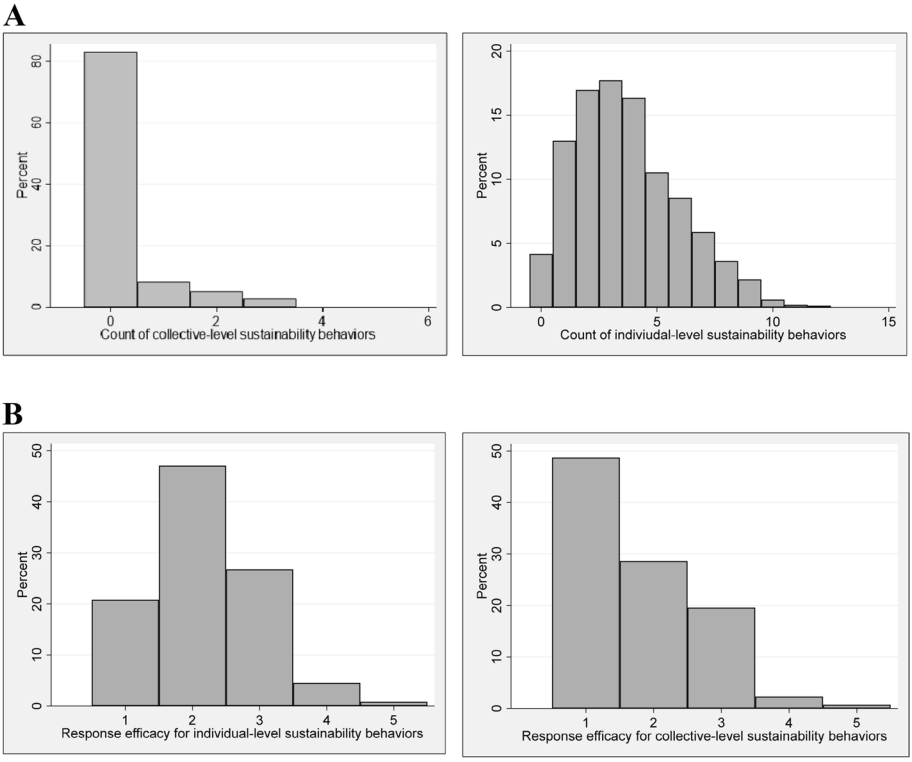

Fig. 1 **a** Counts of individual- and collective-level sustainability behaviors (unweighted). **b** Response efficacy regarding individual- and collective-level sustainability behaviors (unweighted)

Table 3 presents correlations between key study variables, including individual- and collective-level sustainability behaviors, emotions about one's ability to act to address climate change (i.e., behavioral emotions), natural disaster worry, general climate change worry, and response efficacy. Responses were highly correlated across most items.

3.3 Correlates of individual- and collective-level sustainability behaviors

Performing more individual-level sustainability behaviors in the past week was associated with female gender (IRR = 1.15, 95% CI, 1.03, 1.29, $p = 0.014$), older age (IRR = 1.01, 95% CI, 1.002, 1.01, $p = 0.007$), obtaining a bachelor's degree or higher (IRR = 1.15, 95% CI, 1.02, 1.29, $p = 0.019$), and identifying more strongly as a Democrat compared to a Republican (IRR = 1.06, 95% CI, 1.04, 1.09, $p < 0.001$). Demographic correlates of performing more collective-level sustainability behaviors were younger age (IRR = 0.99, 95% CI, 0.97, 0.99, $p = 0.033$), obtaining a bachelor's degree or higher (IRR = 2.02, 95% CI, 1.28, 3.18, $p = 0.002$), and identifying more strongly as a Democrat compared to a Republican (IRR = 1.39, 95% CI, 1.25, 1.55, $p < 0.001$). See Supplemental Table 7 for full results from analyses of demographic correlates of individual- and collective-level sustainability behaviors.

Table 2 Descriptive statistics for behavioral emotions, natural hazard worry, and general climate change worry

	Mean	Standard Deviation	Range
Behavioral emotions			
Hopeful	2.27	0.80	1–4
Confident	2.18	0.76	1–4
Optimistic	2.27	0.81	1–4
Helpless	2.06	0.82	1–4
Powerless	2.12	0.84	1–4
Lacking control	2.16	0.85	1–4
Indifferent	2.10	0.89	1–4
On edge	1.78	0.72	1–4
Uneasy	1.83	0.75	1–4
Nervous	1.77	0.74	1–4
Positive behavioral emotions (composite)	2.24	0.74	1–4
Negative behavioral emotions (composite)	1.96	0.65	1–4
Total behavioral emotion intensity (composite)	2.10	0.52	1–4
Natural hazard worry	1.81	0.69	1–5
General climate change worry	2.19	1.16	1–5

Weighted Ns and %s presented

Table 4 presents results from Poisson regressions predicting the number of individual-level sustainability behaviors performed in the past week. In model 1, composite positive behavioral emotions were positively associated with individual-level sustainability behaviors. This association remained statistically significant after controlling for natural hazard worry, which was also significant (see model 2). However, as illustrated in model 3, natural hazard worry was no longer significant after accounting for climate change worry. In model 4, response efficacy was significantly associated with individual-level sustainability behaviors and accounted for the relationship between positive behavioral emotions and individual-level sustainability behaviors. In the final model (model 4), the only significant demographic correlates of individual-level sustainability behaviors were older age and obtaining a bachelor's degree or higher. Tests of interaction effects between behavioral emotions, worry, and response efficacy were largely not significant. However, there was a significant interaction between both positive and negative behavioral emotions and natural hazard worry (positive emotions: IRR = 0.86, 95% CI, 0.76, 0.98, $p = 0.028$; negative emotions: IRR = 0.85, 95% CI, 0.75, 0.96, $p = 0.010$). Analyses were replicated by combining positive and negative behavioral emotions into composite behavioral emotional intensity; the pattern of results remained consistent. See Supplemental Table 8.

Table 5 presents the results from Poisson regressions predicting the number of collective-level sustainability behaviors performed in the past year. In model 1, both composite positive and negative behavioral emotions were significant correlates of collective-level sustainability behaviors; positive emotions remained significant after controlling for the significant association between natural hazard worry and collective-level sustainability behaviors (see model 2). However, natural hazard worry was no longer significant after controlling for general climate change worry (see model 3). In fully adjusted models, response efficacy was significantly associated with collective-level sustainability behaviors and accounted for the association between positive behavioral emotions and collective-level

Table 3 Correlations between key study variables: behavioral emotions, worry, response efficacy, and individual- and collective-level sustainability behaviors ($N = 1479$)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1.00																	
2	**0.35**	1.00																
3	**0.25**	**0.24**	1.00															
4	**0.19**	**0.18**	**0.85**	1.00														
5	**0.19**	**0.18**	**0.81**	**0.82**	1.00													
6	**0.16**	**0.16**	**0.17**	**0.11**	**0.13**	1.00												
7	**0.12**	**0.14**	**0.13**	**0.10**	**0.14**	**0.84**	1.00											
8	**0.15**	**0.15**	**0.14**	**0.09**	**0.15**	**0.76**	**0.83**	1.00										
9	**−0.04**	−0.08**	−0.01	−0.01	0.01	**0.16**	**0.17**	**0.17**	1.00									
10	**0.21**	**0.10**	**0.27**	**0.21**	**0.24**	**0.54**	**0.46**	**0.53**	**0.18**	1.00								
11	**0.17**	**0.09**	**0.25**	**0.20**	**0.23**	**0.56**	**0.51**	**0.57**	**0.13**	**0.80**	1.00							
12	**0.19**	0.06*	**0.24**	**0.21**	**0.22**	**0.47**	**0.42**	**0.50**	**0.13**	**0.76**	**0.81**	1.00						
13	**0.22**	**0.21**	**0.94**	**0.94**	**0.93**	**0.15**	**0.13**	**0.13**	0.00	**0.26**	**0.24**	**0.24**	1.00					
14	**0.20**	**0.14**	**0.24**	**0.18**	**0.22**	**0.85**	**0.83**	**0.86**	**0.19**	**0.81**	**0.84**	**0.78**	**0.23**	1.00				
15	**0.28**	**0.23**	**0.25**	**0.20**	**0.24**	**0.38**	**0.32**	**0.33**	**0.05**	**0.41**	**0.40**	**0.40**	**0.24**	**0.45**	1			
16	**0.30**	**0.31**	**0.27**	**0.26**	**0.25**	**0.43**	**0.40**	**0.42**	**−0.15**	**0.39**	**0.46**	**0.43**	**0.28**	**0.51**	**0.68**	1.00		
17	**0.38**	**0.20**	**0.43**	**0.37**	**0.36**	**0.23**	**0.20**	**0.24**	−0.06*	**0.28**	**0.31**	**0.33**	**0.41**	**0.31**	**0.26**	**0.35**	1.00	
18	**0.28**	**0.30**	**0.41**	**0.39**	**0.37**	**0.13**	**0.11**	**0.13**	**−0.09**	**0.19**	**0.17**	**0.23**	**0.42**	**0.19**	**0.26**	**0.36**	**0.55**	1.00

1. Collective-level sustainability behaviors 2. Individual-level sustainability behaviors 3. Hopeful 4. Confident 5. Optimistic 6. Helpless 7. Powerless 8. Lacking control 9. Indifferent 10. On edge 11. Uneasy 12. Nervous 13. Positive emotions (composite) 14. Negative emotions, (composite) 15. Natural hazard worry 16. General climate change worry 17. Collective-level behavioral response efficacy 18. Individual-level behavioral response efficacy

Bold = $p < .001$; *$p < .05$, **$p < .01$

Table 4 Poisson regression analyses of demographics, positive and negative behavioral emotions, worry, and response efficacy as correlates of individual-level sustainability behaviors

	Model 1 ($N=1412$)				Model 2 ($N=1412$)				Model 3 ($N=1411$)				Model 4 ($N=1408$)			
	IRR	95% CI		*p*	IRR	95% CI		*p*	IRR	95% CI		*p*	IRR	95% CI		*p*
Ethnicity[a]																
Black, Non-Hispanic	0.90	0.71	1.14	.368	0.86	0.68	1.09	.217	0.89	0.70	1.12	.310	0.85	0.68	1.07	.174
Non-Hispanic, 2+races	0.96	0.70	1.33	.819	0.94	0.69	1.27	.683	0.94	0.68	1.29	.687	0.94	0.68	1.29	.700
Hispanic	1.00	0.87	1.16	.953	0.94	0.81	1.08	.368	0.93	0.81	1.08	.351	0.92	0.80	1.07	.282
Female gender[b]	**1.12**	**1.00**	**1.25**	**.044**	1.10	0.98	1.22	.096	1.10	0.99	1.23	.067	1.08	0.97	1.20	.160
Income	1.03	0.99	1.06	.115	1.03	0.99	1.06	.108	1.03	0.99	1.06	.144	1.02	0.99	1.05	.255
Age	**1.01**	**1.002**	**1.01**	**.002**	**1.01**	**1.002**	**1.01**	**.004**	**1.01**	**1.001**	**1.01**	**.011**	**1.01**	**1.001**	**1.01**	**.010**
Bachelor's degree or higher[c]	**1.14**	**1.01**	**1.29**	**.032**	**1.17**	**1.04**	**1.32**	**.009**	**1.15**	**1.02**	**1.30**	**.020**	**1.16**	**1.03**	**1.31**	**.015**
Party ID[d]	**1.04**	**1.01**	**1.08**	**.005**	**1.05**	**1.01**	**1.08**	**.005**	1.03	0.99	1.06	.199	1.02	0.98	1.06	.350
Positive behavioral emotions	**1.18**	**1.09**	**1.29**	**<.001**	**1.15**	**1.06**	**1.25**	**.001**	**1.14**	**1.05**	**1.24**	**.001**	1.08	0.99	1.19	.084
Negative behavioral emotions	1.10	0.99	1.21	.066	1.01	0.91	1.13	.793	0.98	0.88	1.08	.635	0.98	0.89	1.09	.757
Natural hazard worry					**1.19**	**1.06**	**1.34**	**.003**	1.07	0.91	1.27	.408	1.07	0.91	1.25	.431
Climate change worry									**1.12**	**1.04**	**1.22**	**.005**	**1.10**	**1.01**	**1.20**	**.021**
Response efficacy													**1.15**	**1.07**	**1.24**	**<.001**
Constant	0.91	0.59	1.40	.663	0.85	0.54	1.34	.483	0.99	0.63	1.58	.980	0.92	0.57	1.47	.722
Model statistics	Wald $X^2(10)=61.73$, $p<.001$				Wald $X^2(11)=70.73$, $p<.001$				Wald $X^2(12)=99.10$, $p<.001$				Wald $X^2(13)=114.77$, $p<.001$			

Ns vary due to missing data. $p<.05$ highlighted in bold

[a]White person = 0 (reference group);

[b]Identifies as male = 0 (reference group)

[c]Less than bachelor's degree = 0 (reference group)

[d]7-item measure, 1 = strong Republican to 7 = strong Democrat

Table 5 Poisson regression analyses of demographics, positive and negative behavioral emotions, worry and response efficacy as correlates of collective-level sustainability behaviors

	Model 1 ($N=1415$)				Model 2 ($N=1415$)				Model 3 ($N=1414$)				Model 4 ($N=1338$)			
	IRR	95% CI		*p*	IRR	95% CI		*p*	IRR	95% CI		*p*	IRR	95% CI		*p*
Ethnicity[a]																
Black, Non-Hispanic	0.55	0.26	1.18	.126	0.49	0.23	1.05	.066	0.52	0.24	1.11	.093	**0.42**	**0.20**	**0.90**	**.025**
Non-Hispanic, 2+races	0.48	0.21	1.09	.079	**0.44**	**0.20**	**0.98**	**.044**	**0.42**	**0.19**	**0.93**	**.031**	0.52	0.26	1.02	.058
Hispanic	0.99	0.62	1.59	.973	0.72	0.43	1.19	.203	0.72	0.44	1.17	.185	0.62	0.38	1.01	.052
Female gender[b]	1.35	0.87	2.10	.175	1.18	0.78	1.79	.427	1.27	0.85	1.89	.236	1.22	0.83	1.78	.308
Income	1.02	0.90	1.16	.758	1.00	0.91	1.11	.935	1.01	0.91	1.12	.910	0.96	0.88	1.05	.348
Age	0.99	0.97	1.00	.066	**0.99**	**0.97**	**1.00**	**.035**	**0.98**	**0.97**	**0.99**	**.006**	**0.99**	**0.98**	**1.00**	**.011**
Bachelor's degree or higher[c]	**1.94**	**1.27**	**2.97**	**.002**	**2.21**	**1.45**	**3.37**	**<.001**	**2.16**	**1.41**	**3.28**	**<.001**	**1.88**	**1.26**	**2.83**	**.002**
Party ID[d]	**1.32**	**1.19**	**1.47**	**<.001**	**1.31**	**1.21**	**1.42**	**<.001**	**1.25**	**1.12**	**1.38**	**<.001**	**1.20**	**1.10**	**1.32**	**<.001**
Positive behavioral emotions	**2.06**	**1.41**	**3.02**	**<.001**	**1.87**	**1.27**	**2.75**	**.002**	**1.82**	**1.25**	**2.65**	**.002**	1.37	0.93	2.03	.115
Negative behavioral emotions	**1.46**	**1.04**	**2.05**	**.030**	1.13	0.80	1.58	.494	0.98	0.71	1.35	.897	0.90	0.66	1.22	.491
Natural hazard worry					**1.73**	**1.36**	**2.20**	**<.001**	1.32	0.89	1.94	.168	1.29	0.97	1.72	.079
Climate change worry									**1.44**	**1.15**	**1.82**	**.002**	**1.38**	**1.14**	**1.68**	**.001**
Response efficacy													**1.72**	**1.42**	**2.08**	**<.001**
Constant	**0.01**	**0.002**	**0.02**	**<.001**	**0.01**	**0.002**	**0.02**	**<.001**	**0.01**	**0.003**	**0.03**	**<.001**	**0.01**	**0.00**	**0.03**	**<.001**
Model statistics	Wald $X^2(10)=121.61$, $p<.001$				Wald $X^2(11)=158.75$, $p<.001$				Wald $X^2(12)=206.26$, $p<.001$				Wald $X^2(13)=303.27$, $p<.001$			

Ns vary due to missing data. $p<.05$ highlighted in bold

[a]White person = 0 (reference group)

[b]Identifies as male = 0 (reference group)

[c]Less than bachelor's degree = 0 (reference group)

[d]7-item measure, 1 = strong Republican to 7 = strong Democrat

sustainability behaviors (see model 4). In the final model (model 4), the following demographic indictors were associated with performing more collective-level sustainability behaviors: White persons compared to Black persons, younger age, and obtaining a bachelor's degree or higher. There was a significant interaction between positive behavioral emotions and natural hazard worry (IRR = 0.72, 95% CI, 0.56, 0.93, $p = 0.013$). Analyses were replicated by combining positive and negative behavioral emotions into a composite of emotional intensity; the pattern of results remained consistent. See Supplemental Table 9.

Table 6 presents results for the relationship between discrete behavioral emotions and the number of individual-level sustainability behaviors performed in the past week. Identifying as a White compared to Black person and obtaining a bachelor's degree or higher were positively associated with these sustainability behaviors. General climate change worry accounted for the initial positive relationship between natural hazard worry and performance of individual-level sustainability behaviors (see models 3 and 2, respectively). In the final model, general climate change worry, response efficacy, and feeling hopeful and nervous about one's ability to act were statistically significant correlates of performing individual-level sustainability behaviors. No interaction terms were significant.

Table 7 presents results for the relationship between individual behavioral emotions and the number of collective-level sustainability behaviors performed in the past year. In models adjusting for all covariates (see model 4), performing more collective-level sustainability behaviors was associated with identifying as a White person compared to a Black person, younger age, obtaining a bachelor's degree or higher, and identifying more strongly as a Democrat compared to a Republican. Natural hazard worry, general climate change worry, and response efficacy were significantly associated with performing more collective-level sustainability behaviors; feeling hopeful and confident remained significant as well. No interaction terms were significant.

Post hoc analyses explored if the relationship between political party identification and sustainability behaviors was explained by knowledge about climate change, operationalized via three items (categorized as true/false) assessing knowledge about the causes of anthropogenic climate change. While belief was highly associated with political party identification (beta = 0.44, $p < 0.001$), it did not account for the relationship between political party identification and sustainability behaviors.

4 Discussion

Results suggest uptake of technologies and behaviors that promote sustainability and combat climate change is relatively common: the majority of the sample engaged in at least some individual-level sustainability behaviors in the past week. Although performing collective-level sustainability behaviors was much less common, perhaps because many collective-level actions are performed less frequently (e.g., donating money may occur only semi-annually; signing petitions may only occur during a collective mobilization), a substantial minority engaged in at least one collective action in the past year. In adjusted models, general climate change worry and response efficacy were positively associated with performing more sustainability behaviors. In general, climate change worry fully accounted for the relationships between both composite negative behavioral emotions and natural hazard worry and both individual- and collective-level sustainability behaviors. Response efficacy accounted for the relationships between positive behavioral emotions and both individual- and collective-level sustainability behaviors. However, in models

Table 6 Poisson regression of demographics, discrete behavioral emotions, worry, and response efficacy as correlates of individual-level sustainability behaviors

	Model 1 ($N=1351$)				Model 2 ($N=1351$)				Model 3 ($N=1350$)				Model 4 ($N=1348$)			
	IRR	95% CI		*p*	IRR	95% CI		*p*	IRR	95% CI		*p*	IRR	95% CI		*p*
Ethnicity[a]																
Black, Non-Hispanic	0.87	0.71	1.07	.188	0.83	0.68	1.02	.078	0.85	0.69	1.05	.134	**0.82**	**0.67**	**0.99**	**.048**
Non-Hispanic, 2+races	1.01	0.72	1.41	.966	0.98	0.71	1.34	.877	0.97	0.70	1.36	.864	0.98	0.71	1.36	.918
Hispanic	1.01	0.88	1.17	.879	0.92	0.80	1.07	.285	0.92	0.80	1.07	.282	0.91	0.79	1.05	.200
Female gender[b]	**1.13**	**1.01**	**1.26**	**.029**	1.10	0.99	1.22	.083	1.11	0.99	1.23	.071	1.08	0.97	1.21	.148
Income	1.03	1.00	1.06	.053	1.03	1.00	1.06	.054	1.03	1.00	1.06	.085	1.02	0.99	1.05	.169
Age	**1.01**	**1.00**	**1.01**	**.002**	**1.01**	**1.00**	**1.01**	**.008**	**1.004**	**1.001**	**1.01**	**.015**	**1.005**	**1.001**	**1.01**	**.018**
Bachelor's degree or higher[c]	1.13	1.00	1.28	.051	**1.16**	**1.03**	**1.31**	**.015**	**1.15**	**1.02**	**1.30**	**.027**	**1.16**	**1.02**	**1.31**	**.019**
Party ID[d]	**1.04**	**1.01**	**1.08**	**.015**	**1.04**	**1.01**	**1.08**	**.012**	1.03	0.99	1.07	.152	1.02	0.98	1.06	.273
Emotions																
Hopeful	**1.24**	**1.07**	**1.44**	**.005**	**1.21**	**1.06**	**1.38**	**.005**	**1.22**	**1.07**	**1.39**	**.004**	**1.17**	**1.04**	**1.32**	**.008**
Confident	0.95	0.81	1.11	.520	0.96	0.83	1.10	.536	0.94	0.82	1.08	.380	0.93	0.81	1.06	.259
Optimistic	1.01	0.88	1.17	.866	1.00	0.88	1.14	1.00	1.00	0.88	1.14	.961	0.99	0.88	1.13	.932
Helpless	1.06	0.92	1.22	.412	1.03	0.90	1.18	.681	1.03	0.89	1.18	.731	1.03	0.90	1.17	.696
Powerless	1.02	0.88	1.18	.803	1.03	0.89	1.18	.703	1.02	0.89	1.17	.780	1.04	0.91	1.18	.608
Lacking control	1.06	0.94	1.18	.340	1.05	0.94	1.17	.401	1.03	0.92	1.15	.574	1.02	0.92	1.13	.676
Indifferent	0.94	0.86	1.04	.224	0.94	0.87	1.03	.171	0.97	0.90	1.06	.503	0.97	0.90	1.05	.491
On edge	1.12	0.90	1.38	.309	1.09	0.89	1.34	.382	1.11	0.90	1.36	.323	1.11	0.92	1.33	.282
Uneasy	0.96	0.80	1.16	.671	0.95	0.80	1.13	.557	0.93	0.79	1.10	.414	0.96	0.81	1.12	.588
Nervous	0.89	0.75	1.05	.172	0.87	0.74	1.02	.094	0.86	0.73	1.02	.078	**0.84**	**0.71**	**0.99**	**.033**

Table 6 (continued)

	Model 1 ($N=1351$)				Model 2 ($N=1351$)				Model 3 ($N=1350$)				Model 4 ($N=1348$)			
	IRR	95% CI		p	IRR	95% CI		p	IRR	95% CI		p	IRR	95% CI		p
Natural hazard worry					**1.21**	**1.08**	**1.36**	**.001**	1.10	0.95	1.27	.196	1.09	0.95	1.26	.208
Climate change worry									**1.12**	**1.04**	**1.20**	**.002**	**1.09**	**1.02**	**1.17**	**.016**
Response efficacy													**1.17**	**1.09**	**1.26**	**<.001**
Constant	1.00	0.63	1.60	.998	0.94	0.58	1.53	.809	1.02	0.62	1.68	.935	0.93	0.56	1.56	.793
Model statistics	Wald $X^2(18)=88.33$, $p<.001$				Wald $X^2(19)=104.29$, $p<.001$				Wald $X^2(20)=131.99$, $p<.001$				Wald $X^2(21)=157.34$, $p<.001$			

Ns vary due to missing data. $p<.05$ highlighted in bold

[a]White person = 0 (reference group)

[b]Identifies as male = 0 (reference group)

[c]Less than bachelor's degree = 0 (reference group)

[d]7-item measure, 1 = strong Republican to 7 = strong Democrat

Table 7 Poisson regression of demographics, discrete behavioral emotions, worry, and response efficacy as correlates of collective-level climate change-related sustainability behaviors

	Model 1 ($N = 1353$)				Model 2 ($N = 1353$)				Model 3 ($N = 1352$)				Model 4 ($N = 1284$)			
	IRR	95% CI		*p*	IRR	95% CI		*p*	IRR	95% CI		*p*	IRR	95% CI		*p*
Ethnicity[a]																
Black, Non-Hispanic	**0.48**	**0.25**	**0.93**	**.028**	**0.42**	**0.21**	**0.81**	**.010**	**0.46**	**0.24**	**0.90**	**.022**	**0.38**	**0.20**	**0.73**	**.003**
Non-Hispanic, 2 + races	0.58	0.24	1.39	.221	0.52	0.23	1.19	.122	0.47	0.20	1.10	.081	0.59	0.27	1.28	.182
Hispanic	1.04	0.66	1.65	.862	0.73	0.43	1.23	.242	0.72	0.44	1.20	.208	0.62	0.39	1.00	.052
Female gender[b]	1.32	0.90	1.93	.163	1.19	0.80	1.76	.399	1.23	0.83	1.80	.299	1.22	0.85	1.75	.281
Income	1.01	0.92	1.12	.793	1.00	0.91	1.11	.942	0.99	0.90	1.09	.851	0.97	0.89	1.06	.531
Age	0.99	0.98	1.00	.076	**0.99**	**0.97**	**0.99**	**.031**	**0.98**	**0.97**	**0.99**	**.013**	**0.99**	**0.97**	**1.00**	**.021**
Bachelor's degree or higher[c]	**1.82**	**1.20**	**2.75**	**.004**	**2.02**	**1.34**	**3.04**	**.001**	**1.95**	**1.31**	**2.92**	**.001**	**1.72**	**1.16**	**2.54**	**.006**
Party ID[d]	**1.27**	**1.15**	**1.41**	**< .001**	**1.26**	**1.15**	**1.37**	**< .001**	**1.21**	**1.10**	**1.32**	**< .001**	**1.17**	**1.08**	**1.28**	**< .001**
Emotions																
Hopeful	**2.26**	**1.50**	**3.40**	**< .001**	**2.06**	**1.42**	**2.97**	**< .001**	**2.07**	**1.43**	**2.98**	**< .001**	**1.70**	**1.17**	**2.48**	**.005**
Confident	0.88	0.55	1.40	.581	0.97	0.65	1.46	.891	0.92	0.61	1.39	.707	0.90	0.61	1.33	.608
Optimistic	1.08	0.73	1.59	.703	0.98	0.68	1.41	.898	0.99	0.69	1.43	.971	0.92	0.64	1.32	.652
Helpless	1.40	0.83	2.36	.206	1.30	0.76	2.20	.333	1.30	0.79	2.13	.306	1.31	0.79	2.17	.290
Powerless	0.70	0.38	1.31	.269	0.75	0.40	1.38	.349	0.70	0.40	1.24	.225	0.79	0.46	1.35	.387
Lacking control	1.35	0.89	2.04	.162	1.24	0.83	1.85	.289	1.21	0.83	1.77	.320	1.07	0.73	1.57	.732
Indifferent	0.80	0.60	1.07	.127	**0.75**	**0.58**	**0.96**	**.023**	0.86	0.66	1.13	.277	0.79	0.61	1.03	.080
On edge	1.46	0.86	2.48	.159	1.33	0.77	2.29	.309	1.32	0.79	2.19	.286	1.30	0.79	2.12	.304
Uneasy	0.74	0.39	1.40	.347	0.73	0.38	1.39	.339	0.71	0.41	1.23	.221	0.73	0.44	1.22	.233
Nervous	1.14	0.74	1.77	.555	1.11	0.69	1.77	.674	1.07	0.68	1.67	.775	0.98	0.63	1.51	.917

Table 7 (continued)

	Model 1 ($N=1353$)				Model 2 ($N=1353$)				Model 3 ($N=1352$)				Model 4 ($N=1284$)			
	IRR	95% CI		p	IRR	95% CI		p	IRR	95% CI		p	IRR	95% CI		p
Natural hazard worry					**1.75**	**1.40**	**2.19**	**< .001**	1.31	0.95	1.79	.094	**1.34**	**1.02**	**1.77**	**.036**
Climate change worry									**1.42**	**1.15**	**1.75**	**.001**	**1.33**	**1.11**	**1.60**	**.002**
Response efficacy													**1.74**	**1.42**	**2.14**	**< .001**
Constant	**0.01**	**0.002**	**0.03**	**< .001**	**0.01**	**0.003**	**0.03**	**< .001**	**0.01**	**0.003**	**0.03**	**< .001**	**0.01**	**0.004**	**0.04**	**< .001**
Model statistics	Wald $X^2(18)=229.74$, $p<.001$				Wald $X^2(19)=263.19$, $p<.001$				Wald $X^2(20)=322.42$, $p<.001$				Wald $X^2(21)=390.35$, $p<.001$			

Ns vary due to missing data. $p<.05$ highlighted in bold

[a]White person = 0 (reference group)

[b]Identifies as male = 0 (reference group)

[c]Less than bachelor's degree = 0 (reference group)

[d]7-item measure, 1 = strong Republican to 7 = strong Democrat

examining discrete emotions, hopefulness and nervousness remained significant correlates of performing individual-level sustainability behaviors; hopefulness remained a statistically significant correlate of performing collective-level sustainability behaviors.

With few exceptions, emotions, worry, and response efficacy had parallel relationships with performance of both individual- and collective-level sustainability behaviors. This suggests that similar psychological processes may spur action across types of behavior, increasing the generalizability of findings across behavioral outcomes. Most of the interaction terms tested were not significant, suggesting mediation, rather than moderation. However, the cross-sectional nature of our data precludes true mediation analyses, which requires temporal precedence, where variables are assessed at repeated time points (Kendall et al. 2017).

4.1 Response efficacy as an important correlate of sustainability behaviors

Response efficacy for both individual- and collective-level sustainability behaviors to address climate change were relatively low, in alignment with other recent evidence. For example, in a recent Pew survey, 46% of U.S. residents were very/somewhat confident and 52% were not too/not at all confident in the ability of collective action to mitigate the climate crisis (Bell et al. 2021). Nevertheless, in the present analyses, response efficacy was the strongest and most consistent correlate of engagement in both individual- and collective-level sustainability behaviors. This suggests that even if people feel their efforts are only somewhat effective, they may still be willing to perform them. This may be particularly true for actions that are perceived as easy to perform (Bostrom et al. 2019). Interaction effects were not present between efficacy and behavioral emotions (positive or negative) nor worry. While prior work suggests that fear appeals, along with efficacy statements, tend to elicit the strongest effects (Tannenbaum et al. 2015), our findings suggest these constructs, as experienced by the individual, may operate in tandem, rather than through an amplification effect. This may also speak to the strength of the relationship between response efficacy and sustainability behaviors, as evidenced in meta-analytic findings evaluating factors associated with climate change adaptation behavior (van Valkengoed and Steg 2019): even low amounts of response efficacy may be helpful for motivating behavior, independent of co-occurring emotions.

4.2 Hope and climate change–related sustainability behaviors

Of the specific behavioral emotions assessed, hope consistently remained a statistically significant correlate of performing more individual- and collective-level sustainability behaviors in fully adjusted models. This is consistent with other work conducted on individual-level behaviors including recycling (Ojala 2008) and climate change activism (e.g., carbon tax) targeting the collective level (Bury et al. 2020). These data support the "warm glow effect" of engaging in pro-environmental behaviors described by other scholars (Schneider et al. 2021; Taufik et al. 2015), whereby acting morally leads to positive emotional states (Andreoni 1990). This can occur as both an antecedent of performing sustainability behaviors, as a result of that performance, and through a reciprocal process.

The consistent relationship between hope and behaviors was interesting in light of the overall low reported response efficacy. Prior research demonstrated that hope rose with possibility, rather than probability, of a successful outcome with respect to addressing climate change, which in turn led to greater support for climate change action, suggesting that hope may be especially motivating when the odds of success of a particular goal are low

(Bury et al. 2020). Moreover, our findings support prior work suggesting that hope may be a more effective motivator to promote sustainability behavior than negative emotions like shame or guilt (Markowitz and Shariff 2012).

4.3 Worry as a constructive process to inspire action

As people experience more natural hazards that are exacerbated by climate change, they may perceive greater risk and in turn become more alarmed, fearful, and worried, which may lead to more pro-environmental decisions and sustainability behaviors (Weber 2006). Yet our data show that worry about natural hazards alone is likely not enough to encourage environmental actions: Worry specific to the direct impacts of climate change on the individual or their community may be more potent correlates of behavior. Our findings align with work suggesting that in the case of the existential threat of climate change, worry may be rational and adaptive; sustainability behaviors may be one way to take personal responsibility and mitigate threat (Bouman et al. 2020).

It may be surprising that, worry about the direct threat of the "climate crisis," which can seem abstract (van der Linden et al. 2015) was a stronger correlate of sustainability behaviors than natural hazard worry, an arguably more concrete threat (Spence et al. 2012). Climate change worry could indicate respondents are making the cognitive connection between climate change impacts and their personal choices to act to prevent such impacts. Such "subjective attribution" (attributing climate change impacts to the climate crisis) has been associated with more collective "climate activism" (support for a carbon tax policy) and behavioral intentions (e.g., electric vehicle purchase) (Wong-Parodi and Berlin 2022). Similarly, prior work found that attributing a climate-related natural disaster (i.e., hurricane) to the climate crisis was associated with more adaptive behaviors (Wong-Parodi and Garfin 2022). Future research, perhaps integrating both quantitative and qualitative data, could further elucidate these findings.

4.4 Demographic correlates

Similar to prior research, we found some demographic factors associated with performance of sustainability behaviors (Bradley et al. 2020): those older in age were more likely to perform individual-level sustainability behaviors and those younger in age were more likely to perform collective-level sustainability behaviors. Those with a college education reported performing more individual- and collective-level sustainability behaviors. While identifying more strongly as a Democrat compared to a Republican was associated with greater performance of individual- and collective-level sustainability behaviors in preliminary models, after accounting for psychological factors (i.e., behavioral emotions, worry, and response efficacy), political identity did not predict individual-level behaviors. This finding aligns with large-scale survey data finding that issues of climate change and the environment are becoming increasingly important across the political spectrum (Marlon et al. 2022).

We also found identifying more strongly as a Democrat compared to a Republican was associated with natural hazard worry and climate change worry. In addition to political identification, female gender and identifying as Hispanic were associated with natural hazard worry; identifying as Hispanic was associated with more climate change worry. These findings highlight that worry may be a potential mechanism by which demographic factors indirectly influence sustainability behaviors.

Yet in contrast to global research conducted in Europe (Gregersen et al. 2020), we did not find that worry moderated the association between political identification and behaviors. This suggests communication appeals that focus on non-political psychological responses may be effective at promoting sustainability behaviors across the populace, as more U.S. residents across the political spectrum agree that climate change is anthropogenic and should be addressed (Leiserowitz et al. 2021b).

4.5 Applications

Taken together, our findings suggest that practical appeals that focus on hope, efficacy, and personal relevance may be most helpful at inspiring sustainability behaviors (Ojala et al. 2021), particularly in a political climate of perceived high polarization (Lee 2022). Response efficacy in particular may be an important construct to target to increase sustainability behaviors: while it was a robust correlate of behavior, overall it was quite low. While this may be due to the magnitude of the escalating climate change crisis and the inherent limit of what any individual action can to do address it, this also suggests there is ample room to increase feelings of efficacy in the populace, which in turn could encourage more behavior. While general climate change worry was associated with performance of sustainability behaviors, worry about natural hazards and negative behavioral emotions were accounted for by that relationship. This suggests climate change–related communications designed to encourage sustainability behaviors may be most relevant when targeting an individual's specific goals and concerns (Brosch 2021). Furthermore, communications should concurrently leverage feelings of anticipatory hope, perhaps as an antidote to that worry. Indeed, hope appeals can promote greater feelings of self- and response efficacy (Chadwick 2015), potentially further motivating change. Our research supports the notion that worry and fear, particularly when combined with feelings of efficacy, may be effective at promoting adaptive behaviors (Witte and Allen 2000). Relatedly, recent qualitative research found greater than expected "common ground" across the political spectrum with respect to emotions and environmentalism (Kennedy and Muzzerall 2022). Non-politicized messaging that focuses on hope appeals and general concern may be most effective at promoting sustainability behaviors across the populace.

4.6 Limitations and future directions

We note several limitations and provide suggestions to extend this work. Although we assessed a probability-based, representative sample of Texas and Florida residents, our key variables were assessed cross-sectionally, prohibiting analysis of how these factors play out over time. While we presented a snapshot of the populace exposed to repeated hazards in Texas and Florida, future research should examine if results replicate in other regions exposed to localized threats (e.g., wildfires, flooding, and mudslides in California). We did not conduct experimental research that tested variability in how differently valanced climate change communications (e.g., information only, risk focused, positive, negative) correlate with emotional responses and sustainability behaviors. We could not assess the "stickiness" of such messaging responses nor how they may persist in the context of alternative appeals. For example, we could not test if hope-related appeals are resilient in the face of negative messaging. We suggest future experimental research explore these questions further.

Our measures of behaviors were self-report; future research should validate self-reports with behavioral observations. Our previously implemented measure of sustainability behaviors was a simple checklist and did not account for effort of impact, which could be a fruitful area of future research. However, those types of measures may also have weaknesses. For example, it may be easier for those who own a home to drive an electric vehicle; those in urban areas have easier access to public transportation. Thus, our goal was not to capture the total impact these actions have on the environment nor the effort they require, but rather to capture the emotional responses people have to participating in sustainability behaviors more generally.

Furthermore, individual actions were assessed in the past week, while collective actions were assessed in the past year, potentially resulting in recall bias. We believe this is the most ecologically valid approach to assessing these constructs since lifestyle behaviors and household decisions (e.g., conserving energy) are generally performed on an ongoing basis and collective behaviors tend to be more sporadic (e.g., annual contributions to environmental groups, helping a community prepare for climate change impacts). As in all survey research, it is possible that respondents misinterpreted our questions (for example, interpreting our questions as new, rather than ongoing behaviors). Moreover, while most respondents (91%) reported performing at least one sustainability behavior, far fewer reported performing collective sustainability behaviors. Thus, it may have been difficult for those who did not perform behaviors to report on how effective they may be. We assessed a limited number of behavioral emotions, particularly positive ones. There may be emotions that we did not assess that may also be correlated with outcomes. Since the parent study was longitudinal, it is possible that those who continued to take the survey were more interested in the topics we assessed than those who did not. However, our weighting procedure accounted for attrition over time, assuring that the sample utilized in the present manuscript was representative of the target population.

4.7 Conclusion

Our data suggest that hope, worry, and response efficacy are potent correlates of engaging in individual- and collective-level sustainability behaviors. In general, these effects were evident across demographic groups, including political identification. This suggests that to inspire positive action to address the climate crisis, communications should limit partisanship and convey urgency and risk regarding the crisis, focusing on reducing the psychological distance to the crisis and activating motivating amounts of worry, fear, and ruminative processes, while acknowledging that non-constructive worry can have negative impacts on functioning (Holman et al. 2020). Concurrently, messages should also focus on hope and inspire efficacy that despite seemingly dismal odds, engaging in lifestyle choices, household decisions, and climate activism are important behaviors for creating meaningful change.

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Author contribution DRG and GWP jointly contributed to the study conception, design, and funding acquisition. Data analysis was performed by DRG. The first draft of the manuscript was written by DRG. MZ assisted with the literature review and the initial draft. GWP commented on iterative versions of the draft and assisted with editing. All authors provided edits to the final draft and approved of the submission.

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Data availability Data and analytic codes will be available on the Open Science Framework after publication and are available from the authors by request.

Declarations

Conflict of interest The authors declare no competing interests.

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