

# Earth's Future

## RESEARCH ARTICLE

10.1029/2022EF002912

### Key Points:

- Workplace experiences in the geosciences differ by gender, race and ethnicity, sexual orientation, ability status, and career stage
- Historically excluded groups report more negative workplace environments and negative career outcomes
- Diversity, equity, and inclusion efforts need to address hostile behavior effects on careers and retention in the geosciences

### Supporting Information:

Supporting Information may be found in the online version of this article.

### Correspondence to:

E. Marin-Spiotta,  
[marinspiotta@wisc.edu](mailto:marinspiotta@wisc.edu)

### Citation:

Marin-Spiotta, E., Diaz-Vallejo, E. J., Barnes, R. T., Mattheis, A., Schneider, B., Berhe, A. A., et al. (2023). Exclusionary behaviors reinforce historical biases and contribute to loss of talent in the Earth sciences. *Earth's Future*, 11, e2022EF002912. <https://doi.org/10.1029/2022EF002912>

Received 23 MAY 2022

Accepted 10 NOV 2022

### Author Contributions:

**Conceptualization:** Erika Marin-Spiotta, Rebecca T. Barnes, Allison Mattheis, Blair Schneider, Asmeret Asefaw Berhe, Meredith G. Hastings, Billy M. Williams  
**Data curation:** Emily J. Diaz-Vallejo, Vicki Magley

**Formal analysis:** Erika Marin-Spiotta, Emily J. Diaz-Vallejo, Rebecca T. Barnes, Allison Mattheis, Vicki Magley

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## Exclusionary Behaviors Reinforce Historical Biases and Contribute to Loss of Talent in the Earth Sciences

Erika Marin-Spiotta<sup>1</sup> , Emily J. Diaz-Vallejo<sup>1</sup> , Rebecca T. Barnes<sup>2</sup> , Allison Mattheis<sup>3</sup> , Blair Schneider<sup>4</sup> , Asmeret Asefaw Berhe<sup>5</sup> , Meredith G. Hastings<sup>6</sup> , Billy M. Williams<sup>7</sup>, and Vicki Magley<sup>8</sup>

<sup>1</sup>Department of Geography, University of Wisconsin-Madison, Madison, WI, USA, <sup>2</sup>Colorado College, Environmental Studies Program, Colorado Springs, CO, USA, <sup>3</sup>Division of Applied and Advanced Studies, California State University, Los Angeles, CA, USA, <sup>4</sup>Kansas Geological Survey, Lawrence, KS, USA, <sup>5</sup>Department of Life and Environmental Sciences, University of California, Merced, Merced, CA, USA, <sup>6</sup>Department of Earth, Environmental, and Planetary Sciences, Institute at Brown for Environment and Society, Brown University, Providence, RI, USA, <sup>7</sup>American Geophysical Union, Washington, DC, USA, <sup>8</sup>Department of Psychology, University of Connecticut, Storrs, CT, USA

**Abstract** Geosciences remain one of the least diverse fields. Efforts to diversify the discipline need to address the role of hostile and exclusionary work and learning environments. A workplace climate survey distributed to five professional organizations illustrates varied experiences of earth and space scientists over a 12-month period (pre-COVID). A majority experienced positive interactions in the workplace. However, scientists of color, women and non-binary individuals, scientists with disabilities, and lesbian, gay, bisexual, queer, pansexual, and asexual (LGBQPA+) scientists more frequently experienced negative interactions, including interpersonal mistreatment, discriminatory language, and sexual harassment. Geoscientists of color were more likely to experience devaluation of their work than white scientists. More than half of women and non-binary respondents, as well as those who identify as LGBQPA+ experienced identity-based discriminatory remarks. Disabled geoscientists were more likely to hear negative identity-based language than those who did not disclose a disability. Overall, 14% of all respondents experienced sexual harassment in the previous year. Rates were greatest for historically excluded groups: non-binary (51%), LGBQPA+ (33%), disabled (26%), women (20%), and geoscientists of color (17%). A majority of geoscientists reported avoiding their colleagues and almost a third considered leaving their institution or a career change. Historically excluded groups were more likely to report opting out of professional activities with potential career consequences. To address continued exclusion and low retention in the earth and space sciences, recruitment is not enough. We need to create environments that ensure opportunities for all to thrive.

**Plain Language Summary** The earth and space sciences are among the least diverse fields. Efforts to diversify the geosciences often focus on recruitment. However, we have not created environments where all geoscientists can thrive. Data collected from a workplace climate survey distributed through five professional organizations illustrates the varied experiences of earth and space scientists over the previous year (pre-COVID). A large majority experienced positive interactions in the workplace. However, scientists of color, women, scientists with disabilities, non-binary and LGBQPA+ (lesbian, gay, bisexual, queer, pansexual, and asexual) scientists more frequently experienced negative interactions at work compared to their colleagues. Geoscientists of color were more likely to have their work devalued than white scientists. More than half of women and non-binary respondents, as well as LGBQPA+ scientists experienced identity-based discriminatory remarks. Disabled scientists were more likely to hear negative identity-based language than those without a disability. Rates of sexual harassment were greatest among historically excluded groups. Historically excluded groups were more likely to report opt-out activities that can have negative professional consequences.

## 1. Introduction

Efforts to diversify science, technology, engineering, mathematics, and medicine (STEMM) that focus solely on recruitment and individual professional development fail to account for discriminatory practices and behaviors that create chilly (Biggs et al., 2018; Britton, 2017; Cabay et al., 2018; Miner et al., 2019) or outright hostile environments (Clancy et al., 2017; Restrepo Sanín, 2019; Zambrana, 2018). Recent critiques of the leaky pipeline

**Funding acquisition:** Erika Marin-Spiotta, Rebecca T. Barnes, Allison Mattheis, Blair Schneider, Asmeret Asefaw Berhe, Meredith G. Hastings, Billy M. Williams

**Investigation:** Erika Marin-Spiotta, Allison Mattheis, Blair Schneider, Asmeret Asefaw Berhe, Meredith G. Hastings

**Methodology:** Erika Marin-Spiotta, Rebecca T. Barnes, Allison Mattheis, Blair Schneider, Asmeret Asefaw Berhe, Meredith G. Hastings, Billy M. Williams, Vicki Magley

**Project Administration:** Erika Marin-Spiotta, Rebecca T. Barnes, Allison Mattheis, Blair Schneider, Asmeret Asefaw Berhe, Meredith G. Hastings

**Resources:** Erika Marin-Spiotta, Rebecca T. Barnes, Allison Mattheis, Blair Schneider, Asmeret Asefaw Berhe

**Supervision:** Erika Marin-Spiotta

**Validation:** Allison Mattheis, Vicki Magley

**Writing – original draft:** Erika Marin-Spiotta, Emily J. Diaz-Vallejo, Rebecca T. Barnes

**Writing – review & editing:** Erika Marin-Spiotta, Emily J. Diaz-Vallejo, Rebecca T. Barnes, Allison Mattheis, Blair Schneider, Asmeret Asefaw Berhe, Meredith G. Hastings, Billy M. Williams, Vicki Magley

model highlight the need to address how systemic biases and hostile environments affect the retention of historically excluded groups (Berhe et al., 2022; Marin-Spiotta et al., 2020; Puritty et al., 2017; Tajmel, 2019).

The geosciences continue to be one of the least diverse disciplines in the United States and United Kingdom (Beane et al., 2021; Bernard & Cooperdock, 2018; Carter et al., 2020; Doney et al., 2021; Gillette, 1972), despite their importance to managing natural resources and mitigating climate change. Recent work has shed light on discriminatory practices and behaviors in the earth sciences (Berhe & Ghezzehei, 2021; Carter et al., 2020; Dutt, 2020). Personal narratives describe outright hostilities experienced by Black geoscientists (Anadu et al., 2020; Morris, 2021; Raji & Ali, 2021), lesbian, gay, bisexual, transgender, and queer (LGBTQ+) geoscientists (Black, 2019; Larson, 2020; Olcott & Downen, 2020; Pickrell, 2020), women geoscientists (Duncombe, 2019; Willenbring, 2018), disabled geoscientists (Lawrence, 2021) and those at the intersection of two or more discriminated identities (Scarlett, 2021).

One person having harrowing experiences in a discipline is one too many. Quantitative assessment can expand awareness of the prevalence of different types of behaviors to inform organizational interventions (Yost & Gilmore, 2011). Previous surveys in the geosciences have focused primarily on gender (but see Olcott & Downen, 2020). At least half of 370 women surveyed in the early 1980s disclosed experiencing discrimination (Sancetta et al., 1990). Two decades later, 51% of 500 women geoscientists reported experiencing sexual harassment (Archie & Laursen, 2013). An international survey of 1220 earth and space scientists found differences in the experiences and perceptions of gender bias between men and women (Popp et al., 2019).

We conducted a workplace climate survey via five professional organizations in the earth and space sciences through the ADVANCEGeo Partnership, funded by the U.S. National Science Foundation ADVANCE program (Marin-Spiotta et al., 2022). The anonymous survey aimed to (a) quantify the type and frequency of workplace interactions to better understand demographic trends in the discipline; (b) identify areas of greatest need for intervention; and (c) provide a baseline for future assessment of workplace climate in the geosciences. Here we report differences in workplace experience by career stage, gender, sexual orientation, disability status, and race/ethnicity. As the first comprehensive and largest disciplinary-wide workplace climate survey (>2,000 completed surveys) using validated tools, we provide some of the first quantitative evidence of the frequency and pervasiveness of a range of exclusionary behaviors in our field, with a focus on identities often overlooked by diversity efforts. Understanding how a broad range of historically excluded groups navigate working and learning environments is critical to influence disciplinary-wide efforts for change.

## 2. Materials and Methods

### 2.1. Workplace Climate Survey Development and Distribution

We conducted an anonymous survey of members of the American Geophysical Union (AGU), Geological Society of America (GSA), Soil Science Society of America (SSSA), Association for Women Geoscientists (AWG), and Earth Science Women's Network (ESWN). The survey contained 83 questions (15–20 min long) and was delivered online via Qualtrics in Fall 2019 and early Winter 2020. The survey closed prior to disruptions from COVID-19 in the U.S. and thus generally reflects pre-pandemic workplace conditions. Responses received from the different associations (Table S1 in Supporting Information S1) and that were more than 50% complete (a total of 2141 out of 3426 started surveys) were combined into one data set to represent a sample of the earth and space science community.

The survey contained 12 sections (Supporting Information S1). Here we report data on workplace experiences, defined in the survey as “place or environment where you conduct the majority of your professional activities (work or study),” consequences and outcomes, and perceptions of alcohol presence in professional settings. The survey asked primarily about workplace experiences within the last 12 months. Participants were asked to select from a scale of frequency of exposure (“never”, “once or twice”, “sometimes”, “often”, or “many times (almost weekly)”). We report frequencies for the total survey pool.

Questions included experiences with (a) prosocial behaviors, such as those intended to benefit others through helping and sharing, to identify experiences of positive support (Edmondson, 1999; Sheridan et al., 2016); (b) general incivility or interpersonal mistreatment (Cortina et al., 2001); (c) negative or discriminatory language, adapted from the American Astronomical Society's Committee on the Status of Women in Astronomy (Clancy et al., 2017); and (d) sexual harassment, via the Sexual Experiences Questionnaire (SEQ) to

capture sexual coercion, unwanted sexual attention, and gender harassment (Fitzgerald et al., 1988). We collected demographic information at the end of the survey. The survey design and analysis were reviewed by the Institutional Review Board at the University of Wisconsin-Madison to comply with ethical practices to reduce the risk of breach of confidentiality and for the reduction of harm, especially given the sensitive topics of the questions (see Supporting Information S1 for survey materials). Surveys were anonymous and responses were not linked to membership accounts of any organizations. Potential respondents were informed that their participation was voluntary and would not interfere with any of their organizational membership privileges.

## 2.2. Workplace Climate Survey Data Analysis

For analysis, questions about experiences of incivility, negative or discriminatory language, and sexual harassment were consolidated to reflect broader themes using exploratory factor analysis and published scales. For general incivility, nine items were consolidated into four groups: devaluation of work and efforts, insulting remarks, physical safety, and bullying and intimidation. For negative language, 11 items were consolidated into six groups: negative language about age, gender or sex, sexual orientation, health, race, and religious beliefs. For sexual harassment, 13 items in the SEQ were consolidated into three: sexual coercion, unwanted sexual attention, and gender harassment. We report averages for each themed group of experiences. To simplify statistical comparisons between demographic groups, we coded frequency responses into a binary: “never” versus “at least once.”

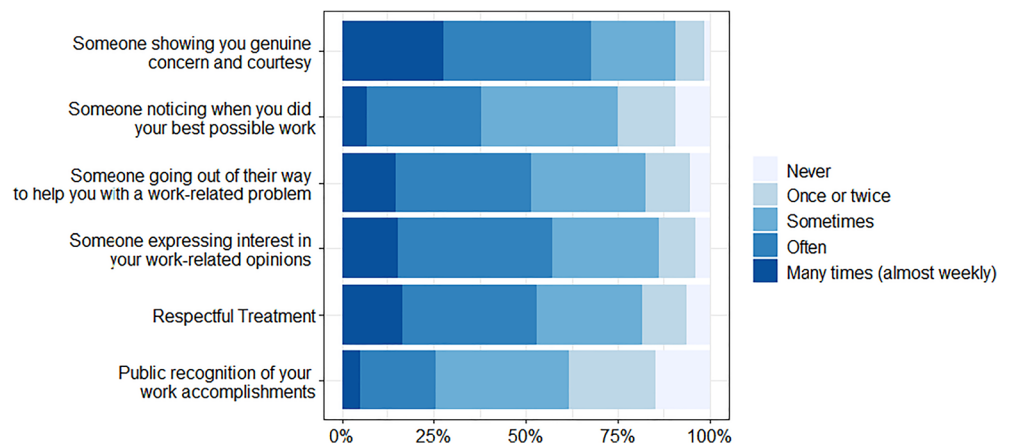
We compared experiences between respondents of historically excluded groups and the overrepresented group within identity-based categories (gender, transgender status, sexual orientation, ability status, race and ethnicity, and career stage), based on demographics of the discipline. Respondents were asked separately about gender (“What is your gender identity? Please select one answer: woman, man, non-binary, other, choose not to answer”), transgender (trans) identity (“Do you identify as transgender? Please select one answer: yes, no, choose not to answer”), and sexuality (“Do you identify as lesbian, gay, bisexual, queer, pansexual, asexual, or any other non-heterosexual orientation? Please select one answer: yes, no, choose not to answer.”), thus we analyzed these categories separately. For example, in our analysis, responses by gender would include cisgender and trans individuals. We use the acronym LGBQPA+ to reflect sexual orientation in our survey findings. We recognize fluidity among these categories and their definitions. Small numbers of survey respondents did not provide demographic information and thus were included in the overall survey pool but not in analyses by identity.

To test for effects of race and ethnicity, we first compared a combined category of respondents of color (including any individuals who selected biracial or multi-racial) to white respondents. Next, we combined selections for a range of racial and ethnic identities (see Table S2 in Supporting Information S1 for survey classifications) into the following: Native or Indigenous; Black; Latinx; Middle Eastern; and Asian, Asian American and Pacific Islander (AAAPI) groups. We recognize that the terminology used to classify people into groups can be problematic and intentionally use broad categories, which do result in homogenization across different lived experiences. Because sample sizes were relatively small for some of the groups, we compared each separately to experiences of white respondents, rather than analyze differences among all racial and ethnic categories. Individuals who selected more than one race or ethnicity were included in more than one paired comparison, as appropriate. We are combining data from this and a similar survey of the ecological sciences (Primack et al., 2022) to test for the effect of intersectionality.

We performed a logistic regression with an analysis of variance using a chi-square distribution, given highly unequal sample sizes, to test for differences in workplace experiences and professional consequences between demographic groups within each identity category. For responses with a sample size below five, we conducted a Fisher's test. All analyses were performed in R 4.0.1 (R Core Team, 2020). We used dplyr to manage and summarize the data (Wickham et al., 2022) and ggplot2 to create figures (Wickham, 2016). Statistical significance was determined at a  $p$ -value  $\leq 0.05$  unless otherwise noted.

## 3. Overview of Respondents

Overall, survey respondents' demographics reflected the U.S. earth and space sciences in terms of race and ethnicity, with 86.1% selecting white and 13.8% selecting one or more other categories (Table S2 in Supporting Information S1). Latinx respondents represented 3%, and Black or African American, Native or Indigenous,



**Figure 1.** Frequency of prosocial behaviors or supportive interactions in the workplace over the prior 12 months in a workplace climate survey of earth and space scientists.

and AAPI respondents each made up less than 1% of the pool. Biracial or multiracial individuals made up 4.6% of respondents.

Women were overrepresented in the survey (50%) compared to the U.S. geoscience (33%) workforce (Gonzales, 2019). Men comprised 46% and non-binary individuals 1.3% of the survey population.

Transgender individuals represented 1% of respondents.

Eleven percent of survey respondents identified as lesbian, gay, bisexual, queer, pansexual, asexual, and other non-heterosexual identities (LGBQPA+).

Respondents who identified as disabled or with a disability were 7% of the total, comparable to a survey of earned U.S. doctorates in engineering (National Center for Science & Engineering Statistics, 2019).

The majority of respondents (70%) held a doctorate, followed by masters (19.1%), or bachelors (10%) as highest degree earned. First-generation graduate degree holders made up 47% and 25% were first-generation undergraduate degree holders. Early career respondents, including any of the student, trainee, and postdoctoral position categories, represented 20% of the total. Most respondents worked or studied in higher education (57%), government (19%), for-profit (8%) or non-profit (5%) organizations, and K-12 education (0.3%).

We did not ask about country of origin or employment, thus we cannot make assumptions about the geographic location of the experiences. The organizations surveyed in this study are U.S.-based and include international membership.

Surveys delivered through established professional associations may undersample students and postdocs, who typically make up lower proportions of the membership. They also do not capture those who have made a career change out of the field. Overrepresentation of women in the survey may reflect participation of two prominent women's organizations in the research. We recognize the limitations in generalizing from our findings to the entire discipline.

## 4. Findings From a Workplace Climate Survey of the Earth and Space Sciences

### 4.1. Positive Interactions With Others in the Workplace

The majority of earth and space scientists (>75%) who responded to the survey experienced prosocial behaviors or positive interactions in the workplace (Figure 1). More than two-thirds (67%) were shown genuine concern and courtesy often or almost weekly. Half indicated being treated with respect often or many times, including almost weekly. Positive interactions occurred more frequently with peers or colleagues, followed by students, trainees, or supervisees, and then supervisors. On the other hand, 31% of respondents indicated never and 28% reported only once or twice experiencing prosocial behaviors from institutional leadership.

The least frequently experienced prosocial behavior was public recognition of work accomplishments. More than half reported experiencing public recognition at least sometimes, including 25% often or almost weekly. In



contrast, more than a third (37%) reported never or only once or twice receiving the same recognition in the prior 12 months (Figure 1).

Whereas large majorities of respondents reported prosocial behaviors, there were differences by identity. Early-career respondents overall experienced greater rates of prosocial behaviors than those in later career stages. Disabled respondents were less likely to experience someone noticing when they did their best possible work or having someone expressing interest in their work-related opinions, although rates were still high (85% and 93%, respectively) (Table S3 in Supporting Information S1). Non-binary individuals were less likely to receive public recognition of their work (79%) than women (83%) or men (87%) ( $p = 0.08$ ) (Table S3 in Supporting Information S1). Trans respondents did not report differences in prosocial behaviors compared to cisgender individuals. There were no significant differences by race and ethnicity in prosocial behaviors, except for Middle Eastern respondents, where 76% reported someone noticing when they did their best possible work compared to 91% of white respondents (Table S4 in Supporting Information S1).

#### 4.2. Experiences of Incivility or Interpersonal Mistreatment

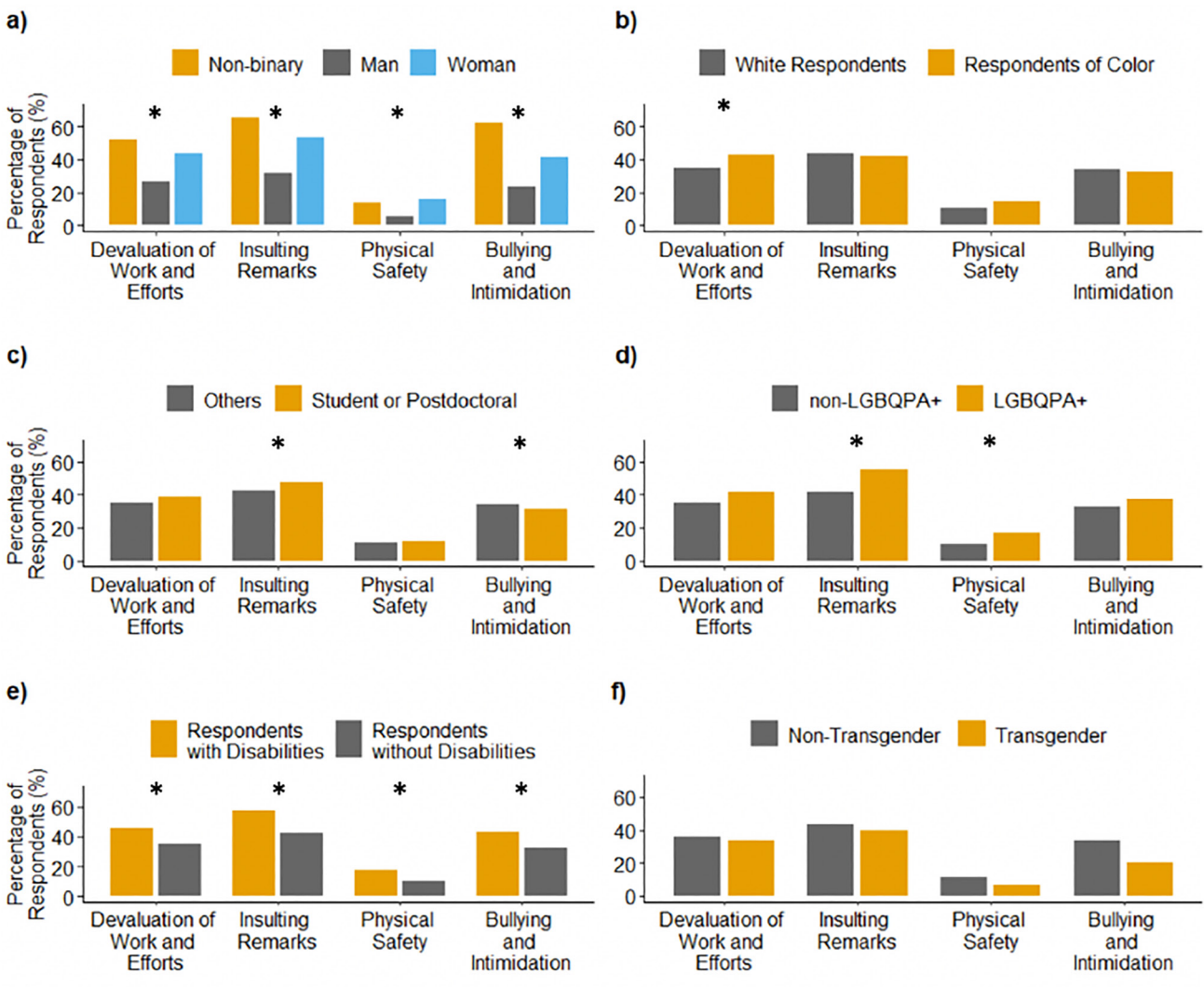
More than 25% of geoscientists surveyed experienced a range of behaviors classified as incivility (Cortina et al., 2001, 2013) at least once over the prior 12 months (Figure S1 in Supporting Information S1). We recognize that the term “incivility” has been used to discriminate and commit violence against Indigenous and Black people in the United States and other settler colonial states. We use it here exclusively to refer to the published literature on interpersonal mistreatment. Andersson and Pearson (1999) defined incivility as behavior with ambiguous intent to harm, in violation of workplace norms for mutual respect and dignity. In our survey, a third experienced devaluation or sabotage of their work or bullying-like and intimidating behaviors (Figure S1 in Supporting Information S1). The most common source of interpersonal mistreatment were peers or colleagues, with 50% of respondents reporting these interactions occurring more than once or twice, often, or almost weekly.

Historically excluded groups and those in more vulnerable positions due to power dynamics experienced more incivility. Students, trainees, and postdoctoral researchers were more likely (40%) to have their work and efforts be devalued or sabotaged than other career stages (35%) (Figure 2; Table S5 in Supporting Information S1).

Geoscientists of color broadly were more likely to experience devaluation of their work and efforts (43%) than white respondents (34%) (Figure 2). More than half of Latinx respondents (55%) reported devaluation of their work, compared to 35% of white respondents (Table S6 in Supporting Information S1). A quarter of Black respondents reported fearing for their physical safety at least once over the past 12 months, compared to 11% of white respondents ( $p = 0.08$ ) (Table S6 in Supporting Information S1). Miner et al. (2017) found that STEM students of color experienced more incivility than their white peers. These experiences influenced psychological stress and sense of scientific-self, which affect retention.

Our survey revealed large differences by gender (Figure 2; Table S5 in Supporting Information S1). Few studies have collected data beyond the gender binary in STEM. Non-binary individuals consistently reported more negative workplace environments, with 62% experiencing intimidating or bullying-like behaviors, followed by 42% of women, and 24% of men. Non-binary respondents were more than twice as, and women a little less than twice as, likely to experience condescending, derogatory, or disrespectful remarks than men. Non-binary respondents and women also were more likely to experience devaluation of their work and fear for their physical safety than men (Figure 2). Others have found that gender minorities (Richey et al., 2020) and gender non-conforming and transgender scientists (Atherton et al., 2016) experienced greater hostility in the workplace. Our survey did not reveal differences in experiences of interpersonal mistreatment between trans and cis respondents.

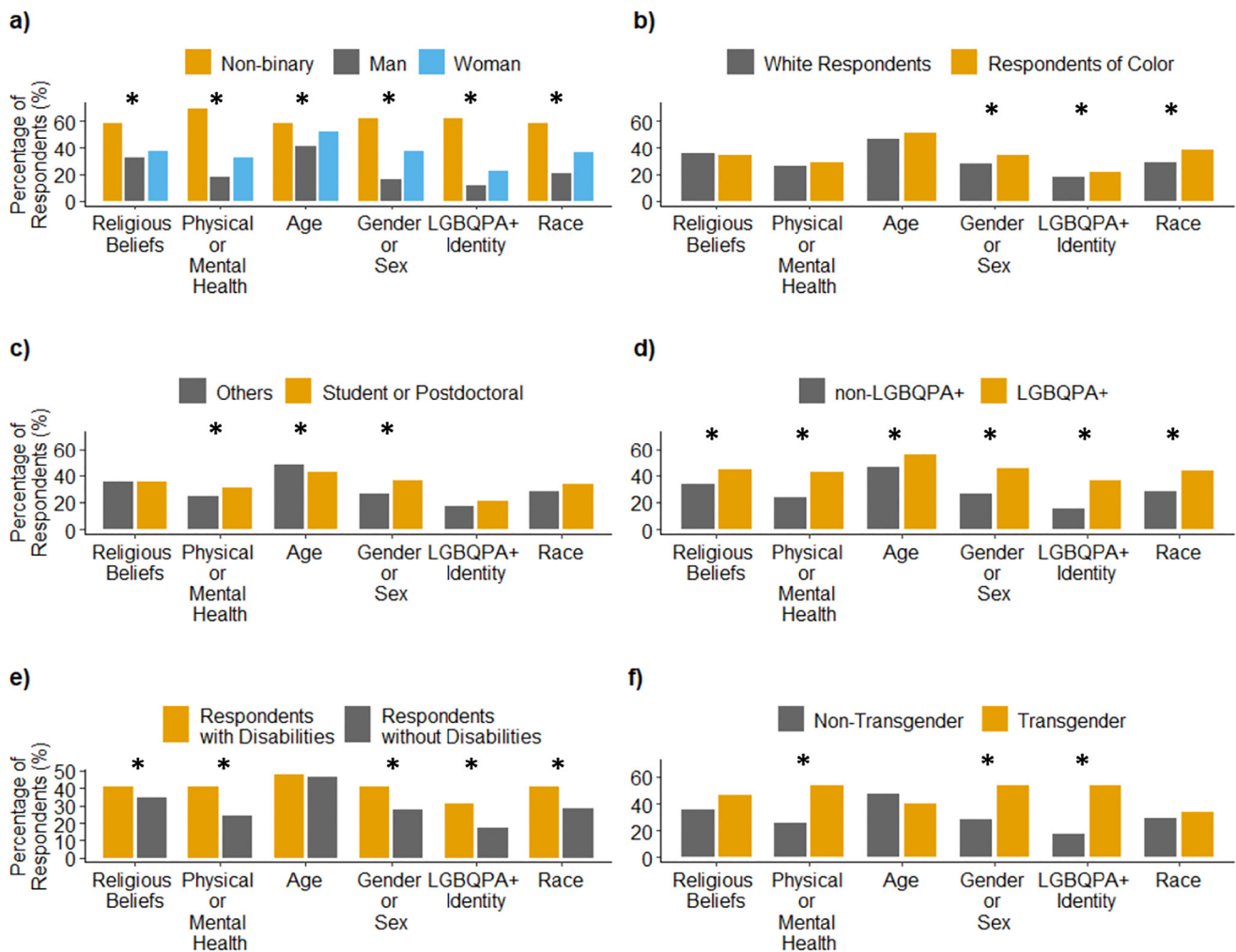
More than half (55%) of LGBQPA+ respondents experienced insulting remarks compared to 41% of those who did not identify as LGBQPA+ (Figure 2). LGBQPA+ geoscientists were more likely to report devaluation of their work and efforts and fear for their physical safety. Another study reporting less supportive workplaces for LGBTQ scientists in disciplines with reduced gender parity, revealed that the earth sciences had one of the lowest degrees of openness about queer identity (Yoder & Mattheis, 2016). LGBTQ individuals in STEM-related U.S. federal organizations also experienced more negative workplaces (Cech & Pham, 2017). More than half (55%) of 261 LGBTQ geoscientists recently surveyed felt unsafe doing fieldwork (Olcott & Downen, 2020). The dominance of expectations of cisgender and heterosexual identities in STEM can lead to indifferent or outright hostile work environments for others (Cech & Waidzun, 2021; Mattheis et al., 2019).



**Figure 2.** Occurrence of interpersonal mistreatment or incivility in the workplace over the prior 12 months in a workplace climate survey of earth and space scientists presented by (a) gender, (b) race and ethnicity, (c) sexual orientation, (d) career stage, (e) ability status and (f) transgender identity. Stars represent significant differences between demographic groups for specific behaviors.

All measures of interpersonal mistreatment were greater for respondents with a disability (Figure 2). Almost half (46%) experienced devaluation of their work and efforts; 43% experienced bullying or intimidating behavior; and more than half (57%) experienced insulting, disrespectful or derogatory remarks. Disabled respondents were also more likely to fear for their physical safety (17% vs. 11%). Others have documented hostile climates and perceptions of STEM as unwelcoming and inaccessible for disabled students (Bettencourt et al., 2018; Lawrence, 2022). Disproportionately negative experiences are likely influenced by ableist perceptions of the geosciences (Atchison & Libarkin, 2016; Bracken & Mawdsley, 2004; Hall et al., 2004).

The prevalence of behaviors related to rudeness, disrespect, condescension, and degradation in the workplace reflect a form of modern discrimination that contribute to maintaining systems of power and privilege (Cortina, 2008), particularly as overt sexism and racism become generally less acceptable (Cortina et al., 2001). Graduate women students in physics and astronomy experienced more gendered microaggressions, including restrictive gender roles, sexist language, and assumptions of inferiority, than outright sexual discrimination (Barthelemy et al., 2016).



**Figure 3.** Occurrence of hearing negative identity-based language in the workplace over the prior 12 months in a workplace climate survey of earth and space scientists presented by (a) gender, (b) race and ethnicity, (c) sexual orientation, (d) career stage, (e) ability status and (f) transgender identity. Stars represent significant differences between demographic groups for specific behaviors.

### 4.3. Negative and Discriminatory Language

Exposure to negative identity-based language was infrequent, yet around 25% of respondents heard some type of disparaging and discriminatory language, whether directed at them or someone else, in the prior 12 months (Figure S2; Table S7 in Supporting Information S1). Almost half (46%) of participants heard remarks related to age (“too young” or “too old”) and 30% heard negative language related to race, gender, and physical and mental health. Most of these interactions occurred with peers or colleagues.

Historically excluded groups were more likely to be exposed to identity-based negative language (Figure 3). Early-career respondents were more likely to hear negative language about race, gender, sexuality, and ability but not age. Geoscientists of color were more likely to hear negative language about race (38%) than white respondents (29%). Latinx respondents were more likely to hear a range of negative identity-based language than white respondents (Table S8 in Supporting Information S1).

Non-binary individuals were the most likely to report hearing discriminatory language, regardless of the targeted identity (Figure 3). Non-binary respondents heard the most negative language about physical and mental health (68%), followed by women (32%), then men (18%). Non-binary respondents were more likely to hear negative comments or remarks about gender (62%), followed by women (38%), then men (16%). Non-binary respondents were more likely (62%) to overhear or be the target of negative language toward people who identify as lesbian,

gay, bisexual, queer, pansexual or transgender, followed by women (22%), then men (11%). Non-binary respondents also were more likely to overhear or receive negative language about race. Men reported hearing more negative remarks about age than any other type, although they were less likely than women or non-binary individuals to hear ageist language.

More than half of trans respondents, significantly more than cis individuals, reported hearing negative language about LGBTQA+ and transgender identities, gender and sex, and physical and mental health.

LGBQPA+ respondents were more likely to hear negative language about age (55% vs. 45%), gender (45% vs. 26%), race (43% vs. 27%), and physical and mental health (43% vs. 23%) than non-LGBQPA+. LGBQPA+ respondents were more likely to overhear or receive negative language toward people who identify as LGBQPA or transgender. Similarly, LGBTQA and nonbinary individuals in astronomy and planetary science reported more sexist language (Richey et al., 2020).

Disabled respondents were more likely to hear negative remarks about race (41% vs. 28%), physical and mental health (41% vs. 24%), gender (41% vs. 27%), and sexual orientation or transgender identity (31% vs. 17%) than those who did not disclose a disability.

Group differences in reported experiences of identity-based discriminatory language likely reflect both intentional targeting as well as greater sensitization to language and/or recognition of its harmful impact.

#### 4.4. Experiences of Sexual Harassment: Gender Harassment as the Common Denominator

Overall, 14% of survey participants reported experiencing sexual harassment at least once in the prior 12 months. Historically excluded groups reported greater rates than the overall average: 51% of non-binary, 33% LGBQPA+, and 26% disabled respondents, 20% women, and 17% people of color (categories are not mutually exclusive) (Figure S3, Table S9 in Supporting Information S1). Sexual harassment occurred mostly during interactions with peers or colleagues (35%), followed by interactions with students, trainees, and supervisees (14%), then supervisors (10%).

The reported prevalence of sexual harassment is comparable to that from previous studies in the geosciences, which used different scales. In a 1983 survey of almost 400 geoscientists, 16% were exposed to unwelcome sexual advances in the workplace (Sancetta et al., 1990). In a 2013 survey of 500 mostly early-career women geoscientists, 10% reported experiencing unwanted sexual attention during the prior 2 years and 51% over their career (Archie & Laursen, 2013).

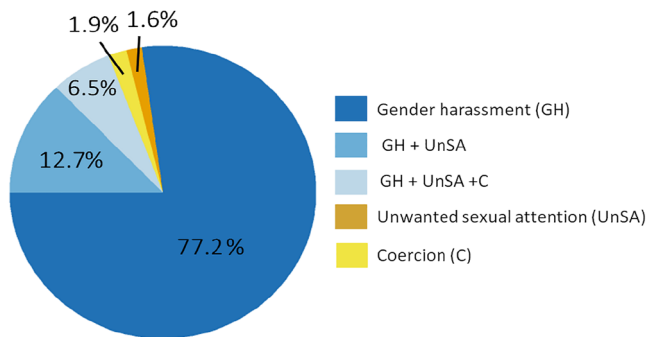
In our survey, students, postdocs, and trainees were almost twice as likely to experience gender harassment and to receive unwanted sexual attention than other career stages and three times as likely to experience sexual coercion, although overall percentages were small (3% vs. 1%) (Table S9 in Supporting Information S1).

Some of the greatest rates of sexual harassment occurred in groups that do not conform to stereotypes of geoscientists (Figure S3 in Supporting Information S1). Non-binary respondents were more likely to experience gender harassment (51%), followed by women (20%), then men (6%). Non-binary respondents (6%) and women (5%) were more likely to report receiving unwanted sexual attention than men (<0.5%). Women were four times more likely to experience sexual coercion than men. A third (33%) of those who experienced sexual harassment identified as LGBQPA+. They also were more likely to experience gender harassment (32% vs. 12%) and unwanted sexual attention (7% vs. 2.5%) than non-LGBQPA+ respondents (Figure S3 in Supporting Information S1). Sexual harassment is often expressed in combination with heterosexist harassment as ways of enforcing traditional, hierarchical, gender norms (Konik & Cortina, 2008). We found that 20% of trans individuals reported experiencing gender harassment and 7% reported experiencing unwanted sexual attention (Table S9 in Supporting Information S1).

Approximately a quarter (26%) of those who experienced sexual harassment identified as disabled. They were more than twice as likely to experience gender harassment (27% vs. 13%) and almost three times as likely to experience unwanted sexual attention (7% vs. 2.5%) than those who did not disclose a disability (Figure S3 in Supporting Information S1).

Our survey did not reveal significant differences in reported experiences of sexual harassment by race and ethnicity over the previous 12 months (Table S10 in Supporting Information S1). An intersectional analysis may reveal





**Figure 4.** Distribution of survey respondents who reported experiencing sexual harassment in the workplace over the prior 12 months by type (gender harassment (GH), unwanted sexual attention (UnSA) and sexual coercion (C)) alone and in combination with gender harassment in a workplace climate survey of earth and space scientists.

interactions between sexual and racial harassment (Buchanan et al., 2009; Cortina et al., 2002).

Gender harassment was the most experienced form of sexual harassment for all groups in our survey, affecting 97% of those who reported at least one behavior in the SEQ (Figure 4). A recent international survey in volcanology documented a range of experiences consistent with gender harassment (Kavanagh et al., 2022). Despite this, it continues to be the least recognized, partly due to misperceptions of sexual harassment to be about sex, and not power (Clancy et al., 2020; Fitzgerald et al., 1995; National Academies of Sciences, Engineering, and Medicine, 2018).

All forms of sexual harassment have harmful consequences on well-being, health, and professional outcomes, and affect retention in STEMM (National Academies of Sciences, Engineering, and Medicine, 2018). In a study of undergraduate women in physics, sexual harassment (which affected 74% of survey respondents) was correlated with reduced feelings of belonging and exacerbated feelings of impostor syndrome (Aycocock et al., 2019).

#### 4.5. Attitudes About Alcohol in Professional Settings

Thirty eight percent of respondents indicated that alcohol is present sometimes, often, or always in professional settings (Table S11 in Supporting Information S1). More than half (56%) stated that alcohol is present often or always and 31% stated that alcohol is present sometimes in meetings and conferences, important places for professional networking. Almost half (47%) stated that alcohol is present during fieldwork.

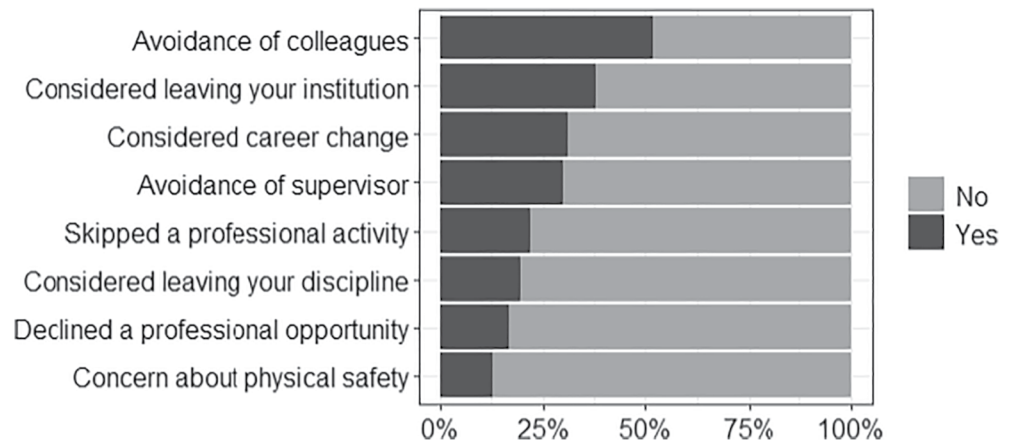
A majority (63%) indicated feeling comfortable with the amount of alcohol consumed in professional settings, with 20% expressing indifference. However, historically excluded and more vulnerable groups expressed greater levels of discomfort (Table S12 in Supporting Information S1). Early-career respondents were more likely to feel uncomfortable (23%) than later career stages (15%). A third of non-binary individuals were less likely to feel comfortable compared to 20% of women, and 13% of men. Similarly, a third of trans respondents reported strongly or somewhat disagreeing with the statement “I am comfortable with the amount of alcohol consumed in professional settings.” Geoscientists of color (23%) were more likely to feel discomfort than white (16%) respondents. We did not explore the many reasons respondents may feel uncomfortable with alcohol in professional environments (Forrester, 2021).

#### 4.6. Negative Experiences Have Professional Consequences

Workplace experiences and interactions can affect career outcomes. Respondents were asked to reflect whether their experiences had affected their behavior at work. Between a quarter to a half of survey respondents reported avoiding others at work, loss of confidence, lowered work productivity, skipping professional activities, or considering career changes (Figure 5).

More than half (50%–68%) of non-binary respondents reported negative career outcomes (Table S13 in Supporting Information S1). They were more likely than women, who were more likely than men, to report concerns for their physical safety, to decline a professional opportunity, skip a professional activity, and consider a career change or leaving the discipline. Non-binary respondents and women were more likely to avoid their colleagues and supervisors than men. A previous study of 91 U.S. academic geoscience faculty revealed that nearly half of the women considered leaving academia, compared to one third of the men (Holmes & O’Connell, 2003). In another study, transgender and gender non-conforming college students were 10% more likely than their cisgender peers to switch out of STEM majors (Maloy et al., 2022). We did not find significant differences between reported career outcomes by transgender identity, but 47% of trans individuals reported avoiding their colleagues at least once in the past year.

LGBQPA+ respondents were more likely than those who did not identify as LGBQPA+ to report avoiding others in the workplace, concerns for their physical safety, and skipping a professional activity (Table S13 in Supporting Information S1). LGBQPA+ respondents were more likely to consider a career change (48% vs. 29%) and to



**Figure 5.** Selection of professional outcomes and consequences ranked in order of most commonly reported in a workplace climate survey of earth and space scientists.

consider leaving their discipline (30% vs. 17%). Exposure to exclusionary behaviors was associated with negative professional outcomes in a survey of LGBT physicists, with over one-third reporting considering leaving their school or workplace (Atherton et al., 2016).

Disabled geoscientists were more likely to skip a professional activity (33% vs. 20%) or to consider a career change (41% vs. 29%) than those who did not report a disability. They also were more likely to consider leaving their discipline (29%) compared to those who did not report a disability (18%).

More than half (55%) of Black respondents reported avoidance of their supervisor compared to 30% of white respondents and were also more likely to report skipping a professional activity (40% vs. 22%) (Table S14 in Supporting Information S1). Percentages of those considering leaving their institution were high across all race and ethnicity groups, ranging from 37% to 50%.

## 5. Conclusions

The workplace climate survey revealed prevalence and frequency of positive and negative behaviors in learning and working environments in the earth and space sciences. While most studies of workplace climate focus on one institution, by working with five professional geoscience societies and associations, our survey captures the experiences of individuals across sectors, career stages, and organizations. Those who do not conform to stereotypes of geoscientists as cisgender, ableist, heteronormative, white men, reported greater interpersonal mistreatment, discriminatory language, and sexualized and gender-based harassment. Even in workplaces where the majority of individuals experienced support and respectful treatment, negative experiences were common, and the same groups disproportionately experienced more negative behaviors. Despite the high frequency of pro-social behaviors, large proportions of respondents reported negative outcomes with professional consequences. While we did not measure retention rates, the disproportionate distribution of negative experiences among historically excluded groups may explain persistent demographic trends in the discipline (Bernard & Cooperdock, 2018).

Groups that have not traditionally been the focus of diversity efforts in STEM, such as non-binary and LGBQPA+ individuals, consistently experienced negative workplaces, including interpersonal mistreatment and sexual harassment. These findings highlight the need for more work at the intersection of gender- and sexuality-based discrimination (Konik & Cortina, 2008). A 2021 study of 21 scientific associations revealed that LGBTQ professionals were more likely to experience harassment, professional devaluation, and exclusion by their peers and were more likely to report intent to leave STEM (Cech & Waidzunas, 2021). More than 20% of LGBT physicists surveyed reported exclusionary behaviors, including sexual and verbal harassment, homophobic comments, exclusion from study groups, and expectations of incompetence (Atherton et al., 2016). Non-binary and transgender individuals are currently discriminated against in the United States and many other countries by enforcement of strong binary gendered definitions and transphobic policies. Efforts to address equity in STEM need to move beyond binary assumptions about gender (DeHority et al., 2021) and address prevalent heterosexism (Miner & Costa, 2018).

Our survey captured less consistent effects of race and ethnicity on workplace experiences as it did for gender, sexual orientation, ability status and career stage. We urge that this not be considered an excuse to dismiss the existence of discriminatory behaviors, rather consider it a legacy of persistent exclusion from the field. Surveys through mainstream professional societies may not necessarily be the best tool to assess experiences of those who may feel unwelcome and excluded from their fields. Efforts to partner with minority-serving organizations and more diverse leadership will be necessary to expand future participation. Our current analysis hides potential differences among and within racial and ethnic groups, including unique experiences of multiracial individuals, the role of citizenship or country of origin, and how intersectionality can further jeopardize workplace climate for individuals with two or more oppressed identities (Bailey & Mobley, 2019; Dickens et al., 2020; Harris et al., 2021; Willis et al., 2019).

Geoscientists of color reported negative professional outcomes and consequences of their workplace experiences (Berhe et al., 2022; Morris, 2021; Raji & Ali, 2021). Half of Black geoscientists who responded to our survey reported considering leaving their institution. Considerations do not necessarily reflect intent or practice. For example, graduate students in chemistry from historically excluded racial and ethnic groups reported greater commitment to completing their PhD and staying in the field, despite more negative experiences (Stockard et al., 2021). Regardless of whether it stems loss of talent from the field, we should actively work toward improving workplace culture and climate because everyone deserves to learn and work in a safe, healthy, welcoming, and equitable environment.

The large percentages of survey respondents who reported hearing disparaging language about a range of identities indicates high levels of ambient exclusionary behaviors (Miner & Costa, 2018). Peers and colleagues were the most common source of negative interactions. Large proportions of respondents indicated avoiding their peers or supervisors, with clear implications for departments and research teams. Access to support networks is critical for building social capital (Croom et al., 2017; Marín-Spiotta et al., 2020; Montgomery, 2018) and can reduce negative effects of interpersonal mistreatment on factors affecting sense of belonging, feelings of scientific competence, and psychological distress, for example, which are known to affect retention in STEMM, especially, but not exclusively, for students of color (Miner et al., 2017). Opportunities for support, mentoring, career development, and community-building, through formal and informal professional networks, can help counteract negative experiences in the workplace (Barnes et al., 2018). This does not remove responsibility from employers and organizational leadership to reduce the prevalence of and mitigate harm from exclusionary behaviors and policies.

To better understand how well (or poorly) different groups are being served by current resources and initiatives, we strongly recommend that professional associations and funding agencies collect a broader range of demographic data, including on gender beyond the binary (DeHority et al., 2021), on race and ethnicity, allowing for self-classification, as well as on sexual orientation, and ability status. Efforts to improve diversity, equity, and inclusion need to address accessibility (Hall et al., 2004; Marshall & Thatcher, 2019), as disabled geoscientists reported experiencing high rates of hostile behaviors. Furthermore, reported levels of discomfort with alcohol for the most vulnerable groups provide support for recent efforts to curb its use in professional settings (Forrester, 2021), including fieldwork (Miller, 2018).

Our research underscores the importance of assessing behaviors, such as bullying and intimidation, interpersonal mistreatment, and discriminatory language, that are not unlawful in many countries but can have harmful impacts on wellbeing, career advancement, and retention. Even with sexual harassment, legal compliance frameworks in the U.S. have been insufficient (National Academies of Sciences, Engineering, and Medicine, 2018). Instead, interventions and mechanisms to change culture and climate are critical (Clancy et al., 2020). The ADVANCE-Geo Partnership, for example, is employing bystander intervention education and the promotion of ethical codes that define harassment, bullying, and discrimination as scientific misconduct as a way to transform workplace climate (Marín-Spiotta, 2018; Marín-Spiotta et al., 2022).

Our research fills a gap in the literature on workplace experiences in STEMM and, especially, in the earth and space sciences. Our study provides some insight into persistent demographic trends in one of the least diverse disciplines. The common occurrence of negative interactions in the workplace demands that organizations immediately assess structures, practices, and policies that sustain and tolerate discriminatory language, harassment, and interpersonal mistreatment (Ali et al., 2021; Cooperdock et al., 2021; Lerback et al., 2022; Marín-Spiotta et al., 2016). Ultimately, efforts to diversify and build equity in the earth and space sciences through recruitment

and professional development will not succeed without serious attention to the commonplace behaviors that contribute to hostile climates and low retention (Ali et al., 2021; Berhe et al., 2022).

The prevalence and discriminatory impact of hostile behaviors hinder the resilience and sustainability of the geosciences as a discipline and of geoscientists as practitioners. Too often we hear “this is not a problem in our discipline” because we did not have the data. We have the responsibility and opportunity to transform the current culture to one that fully values and embraces our colleagues, peers, students, trainees, and coworkers, neighbors, and community members and serves as a model for other STEM disciplines. We can do this by committing to interrogate current stereotypes, behaviors and organizational structures, policies, practices that contribute to a culture of exclusion.

### Conflict of Interest

The authors report funding support from NSF to conduct this research. Williams is employed by AGU. Hastings is President of ESWN and Blair Schneider is Director of the AWG Foundation. Marin-Spiotta, Barnes, and Berhe are former leaders of ESWN.

### Data Availability Statement

De-identified and composited survey data as allowed per the Institutional Review Board is available at <https://doi.org/10.4211/hs.0a9e7010568c40fe953c9368f0ece748>.

### Acknowledgments

We thank Sunita Nandihalli, Kerri Nelson, and Hannah Austin for contributions to early stages of the project. We thank leadership from the American Geophysical Union, Geological Society of America, Soil Science Society of America, Association for Women Geoscientists, and the Earth Science Women's Network for allowing us to survey their membership. We thank Natasha Dowey, Rebecca Williams, and Kijr Hendrickson for thoughtful reviews that improved the manuscript. This work was supported by Human Resources Division Awards 1725879, 1726021, 1725650, 1726163, and 1725424 from the US National Science Foundation ADVANCE program. Marín-Spiotta acknowledges support from a Feminist Scholars Fellowship from the Center for Research on Gender and Women at the University of Wisconsin-Madison.

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