Not Enough: Efforts to Diversify Biogeosciences Benefit Limited Segment of Society

Rebecca T. Barnes[1], Michelle A. Wolford[2], Maya Almaraz[3], and Emily L. Cardarelli[4]

[1]The Belmont Forum, Montevideo, Uruguay

[2] University of Alabama, Department of Biological Sciences, Tuscaloosa, Alabama, USA

[3] Princeton University, High Meadows Environmental Institute, Princeton, New Jersey, USA.

[4]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Corresponding author: Rebecca Barnes (becca.barnes@gmail.com)

Key Points:

- AGU Biogeosciences members and Fall Meeting attendees include more women on average than in the society and Fall Meeting overall.
- Biogeoscience manuscript submissions (73%) and invited reviewers (69%) are dominated by geoscientists identifying as men
- White geoscientists enjoy higher acceptance rates (66%), submit more manuscripts (77%), and receive the most reviewer invites (85%)

Abstract

We examined data from the American Geophysical Union (AGU), the world's largest earth and space science society, to characterize cohort demographics of multiple milestones in a biogeoscientists' career. Geoscientists of color and White women make up a smaller proportion of those participating in activities critical to transitioning from student to professional (submitting manuscripts, getting published, and being asked to review) in comparison to White men. However, gender parity for biogeoscientists appears within reach at earlier career stages, with 37% AGU Biogeosciences members and 41% of Biogeosciences attendees at the Fall Meeting identifying as women in 2020. Unfortunately, data is lacking to make the same assessment for geoscientists of color. A large proportion of manuscripts are submitted by men (73%), many of which have no co-authors that identify as women or non-binary geoscientists, which likely points to inequitable resources and a greater service burden for scientists from historically excluded groups. Further, our communities' bias of *who* we suggest as reviewers results in 85% of the reviewer invites going to White geoscientists and 63% going to men. Thus, while representation of diverse communities has improved in some areas, barriers to publishing results in journals not reflecting society: 25% and 22% of manuscripts were led by or included non-White geoscientists, respectively, and fewer than 5% and 7% were led by or included non-White, women geoscientists, respectively. Therefore, in sectors like academia where publishing remains critical for advancement, this process represents a significant obstacle for biogeoscientists not already part of the majority.

Plain Language Summary

The geosciences remain one of the least diverse STEM fields. We use data from the American Geophysical Union (AGU), the largest scientific society for earth and space scientists, to characterize the demographics of scientists participating in scientific publication and conference activities, which represent milestones in their career. We used information provided on biogeoscientists' gender, race and/or ethnicity, and age to illustrate greater representation trends reached early in one's career (attending a scientific meeting), at career development transitions points (publishing), and in the later more established phase of one's career (invitation to peer review). We found that while the gender gap between people that identify as men and those that identify as women is closing at early career milestones, like that of AGU membership and conference attendance, we do not see this same progress at more advanced career milestones, such as publishing and reviewing. Importantly, we were limited in our ability to draw conclusions about race and ethnicity given a scarcity of representation from ethnically or racially diverse groups. However, we can conclude that biogeoscientists from historically excluded and marginalized groups continue to be underestimated and overlooked during the peer-review publishing process.

1 Introduction

The founder of modern biogeochemistry, Ukrainian scientist Vladimir Vernadsky (1926 *Biosphere*) envisioned the Earth as three spheres: the abiotic sphere, biosphere, and the *Nöesis*, or the sphere of human cognitive process. We all acknowledge the outsized impact that humans apply to the Earth's biogeochemical cycles, [e.g. our activities have tripled the amount of reactive nitrogen cycling within the Earth system (Galloway et al. 2021)]. In contrast, fewer of us explore the role our identities play in studying these cycles (i.e., *Nöesis*). While the scientific method may be unbiased, the questions we ask are influenced by personal experience and a historical lack of diversity in our field limits the array of questions asked. The last five years of social reckoning has forced the (bio)geoscience community to ask ourselves, why? The limited demographic data we have repeatedly points to little progress for geoscientists from undervalued and excluded groups (Bernard & Cooperdock 2018; Raganathan et al. 2021). Evidence points towards the need to create a more inclusive and just work environment (Purrity et al 2017; Zambrana 2019; Sanin 2020; Marin-Spiotta et al. 2023) and to move beyond legal mandates (NASEM 2018; Clancy et al. 2020), if we want our field to be a space where all thrive and push the frontier of innovation (Hofstra et al. 2020; Nielsen et al. 2017).

Representation matters, yet our field has failed to make adequate progress. The geosciences "remain staunchly segregated" (Morris & Washington 2017), lagging behind other STEM fields with respect to racial and ethnic diversity (Dutt 2020) and remaining nearly unchanged over the last forty years (Bernard & Cooperdock 2018). While White women have seen recent gains within the field, they too remain underrepresented, especially in leadership positions. Only 27% of faculty at doctorate granting universities identify as women, with their representation falling with rank from 46% of assistant professors to 19% of full professors (Ranganathan et al. 2021). Demographics by race are more dire, with those identifying as Asian, Black, and Hispanic constituting just 12%, 7%, and 6% of the academic workforce, respectively (Gonzales & Keane 2020).

The attrition of women identifying scientists and/or scientists of color across career milestones, and across STEM fields, is well documented (e.g. Sarraju et al. 2023, Ysseldyk et al. 2019); a pattern commonly referred to as the "leaky pipeline." However, this analogy is fraught with assumptions (Tajmel 2019). In particular, it places the burden on the individual (i.e., the droplets) instead of the cracked system (i.e. problems inherent to the scientific enterprise). Recently, Berhe and colleagues (2022) helped reframe the leaky pipeline as a "hostile obstacle course" to explicitly acknowledge the systemic biases inherent in the geosciences (and STEM more broadly). The (bio)geosciences, like many other fields, have their origin within Western academic scientific organizations, rooted in extractivist, colonial, and imperialist enterprises (Wynn-Grant 2019; Trisos et al. 2021), leaving legacies that vary from discriminatory stereotypes, unspoken cultural norms, and unsafe power dynamics (Bailey et al. 2020; Smith & Griffiths 2022; Marin-Spiotta et al. 2020). Recent studies illustrate the impact of these legacies: scientists who are members of historically excluded groups disproportionately experience negative workplaces in both the geosciences (Marin-Spiotta et al. 2023) and ecological sciences (Primack et al. 2023). These exclusionary practices, especially at the highest ranked institutions, perpetuates the status quo (Ali & Prasad 2021) of who a geoscientist is and what a geoscientist looks like.

In this invited paper, on this occasion of the 20th Anniversary of *Journal of Geophysical Research - Biogeosciences*, we ask: where is our field with respect to generating "the broadest possible community spanning a full spectrum of scientific thought, including those who may not currently engage therein" (Xenopoulos et al. 2022)? Or, in other words, where are we succeeding and where are we continuing to fail? We focus on biogeosciences, but draw on literature from geoscience and ecology more broadly. We use data from the American Geophysical Union (AGU) databases to examine Biogeosciences Section membership, conference attendance, and the publishing process to represent different points within the hostile obstacle course (Berhe et al 2022) for biogeoscientists. Based on these data, we aim to provide snapshots of the inclusivity of a selection of activities (e.g. opportunities to network, present one's work, publish, etc.) critical to fueling a scientist's ability to remain and succeed in the field. This data, in conjunction with a brief literature review, point to the many barriers that persist within the (bio)geosciences, especially for scientists of color, despite the efforts to diversify our field. Thus, we conclude with a summary of available resources created by fellow geoscientists that, if adopted broadly, would signify important steps forward by our collective community.

2 Materials & Methods

2.1 Data

Using American Geophysical Union (AGU) membership data, Fall Meeting attendance, and publication submissions and the paired demographic data, we analyze trends within our research community of biogeosciences to better understand progress and barriers towards diversifying our field. For all quantitative analyses, we used anonymized data from the membership,conference attendance, and publication databases of the AGU, which is the largest earth and space scientific society. The membership data includes self-identified gender (with options being male, female, non-binary, or unknown), and age (as defined by date of birth). Fall Meeting attendance data includes self-identified gender (with the same options as the membership data) and age cohort (e.g., 20s, 30s, 40s, etc.). Membership and attendance data also include the individual's primary and secondary affiliations within the society. Publication data offers the most detailed demographic data of biogeoscientist authors and reviewers, including self-identified or GenderAPI determined gender (with four options: man; woman; non-binary, genderqueer, or Two-Spirit; or prefer not to answer), race/ethnicity (Table S1), and age (as defined by date of birth upon submission). GenderAPI calculated 32.4% of the gender data provided by AGU and has been found to be the most accurate of similar tools (Sebo 2021). Reviewer demographic characteristics are the same as authors in these data, although reviewer's self-identified gender options included non-binary and genderqueer as separate options.

AGU membership and Fall Meeting attendance data allows us to characterize groups of scientists at two, typically early, points in their careers: membership within a scientific society and attending a scientific conference. The AGU then is able to match their membership data on over 110,000 scientists with anonymized author and reviewer data. This merged data set approach was successfully utilized in several past analyses examining the role of identity (Hanson et al. 2020; Lerback & Hanson 2017; Lerback et al. 2020) and COVID-19 (Wooden & Hanson 2022) on the publishing process. Here, we use similar data sets to characterize two additional milestones in a biogeoscientist's career: publication of a peer reviewed paper and being asked to serve as a reviewer.

2.1.1 AGU membership data

We obtained anonymized AGU membership data for 2015 through 2020. Each member data point is identified via a unique "Record ID" that is paired with gender, age, age cohort, primary and secondary affiliation, member type (i.e., regular, life, associate, student, or Berkner), member status (i.e., active or arrears), and year of membership.

2.1.2 AGU Fall Meeting data

We obtained anonymized AGU Fall Meeting attendance data for 2012-2022. The data provided were summarized by year, gender, primary affiliation, age cohort, and country of origin (e.g., 432 attendees in 2022 identified as men from the United States in the Hydrology section). A very small fraction (<0.01%) of attendees provided none of this information.

2.1.3 AGU Journal data

For the bibliometric analyses, we were provided nine years (2012-2021) of data from AGU's two biogeoscience-focused journals: J*ournal of Geophysical Research - Biogeosciences (JGR-B)* and *Global Biogeochemical Cycles (GBC)*. These journal's impact factors were 5 and 7.1 in 2023, respectively (Research.net). Both JGR-B and GBC, like all AGU journals, use a single-blind peer review process, where reviewers and editors know the names of the manuscript's authors, but the authors typically do not know the identities of their reviewers.

The anonymized data obtained from AGU included substantial information on the submission (i.e., submission date, author count, first and final decision dates, number of revisions, final decision, counts of authors by gender, and counts of final reviewers). These data were separated in two manners: one, by author key to separate individual authors by first, corresponding, or contributing author and two, by manuscript ID to group all authors or reviewers on a single paper. As stated above, these authorship and reviewer data sets included gender, age at submission, and race/ethnicity data. To simplify all analyses, 2.6% of data were removed due to indeterminate decisions (i.e., NA or withdrawn).

From 2012 to 2021, 6640 manuscripts were submitted to the *JGR-B* and *GBC*. Of these submissions, 4600 (69.2%) manuscripts have the first authors' gender (man, woman, non-binary) identity. Of the manuscripts which have first authors' gender identity, 32.4% of these identities were derived from a commonly used gender parity index (GenderAPI). Self-reported and GenderAPI data were combined for all analyses unless otherwise stated. A far smaller subset of the 6640 manuscripts (22.4%) had information on authors' race and ethnicity, all of which was self-reported. The proportion of manuscripts with first-author gender and race or ethnicity data did not vary appreciably over time.

2.2 Analysis & Visualization

All data analyses and graphs were completed in the R Programming environment, Version 4.2.2 (R Core Team 2021). Due to the problem of small numbers for many of the geoscientist demographics, statistical analyses were not worthwhile. Further, we want to be transparent about the limitations of the datasets obtained, namely the lack of demographic information: for most members of the biogeoscience community represented herein, race and/or ethnicity information is missing (60-80%) and approximately 30% are missing gender information. We cannot assume geoscientists opt out of providing this information uniformly, and therefore, we want to be careful when interpreting small differences and choose to focus on overall patterns and trends.

3 Results

3.1 AGU membership data 2015-2020

On average, 60,190 scientists (min=58,857 in 2020, max=62,612 in 2019) were members of AGU from 2015 to 2020. The highest membership numbers were in 2018 and 2019, with membership shrinking by 2.5% from 2015 to 2020, likely due to the COVID-19 Pandemic. Over the same time period, the Biogeosciences members, as determined by member-defined primary section affiliation, averaged 8,174 scientists (min=7,339 in 2020, max=8,406 in 2018) with highest membership rates in 2016 and 2018, decreasing by 7% over the five year time period. In 2020, 12.5% of AGU members listed Biogeosciences as their primary or secondary section affiliation, and this number decreased from 13.9% in 2015 (Figure S1).

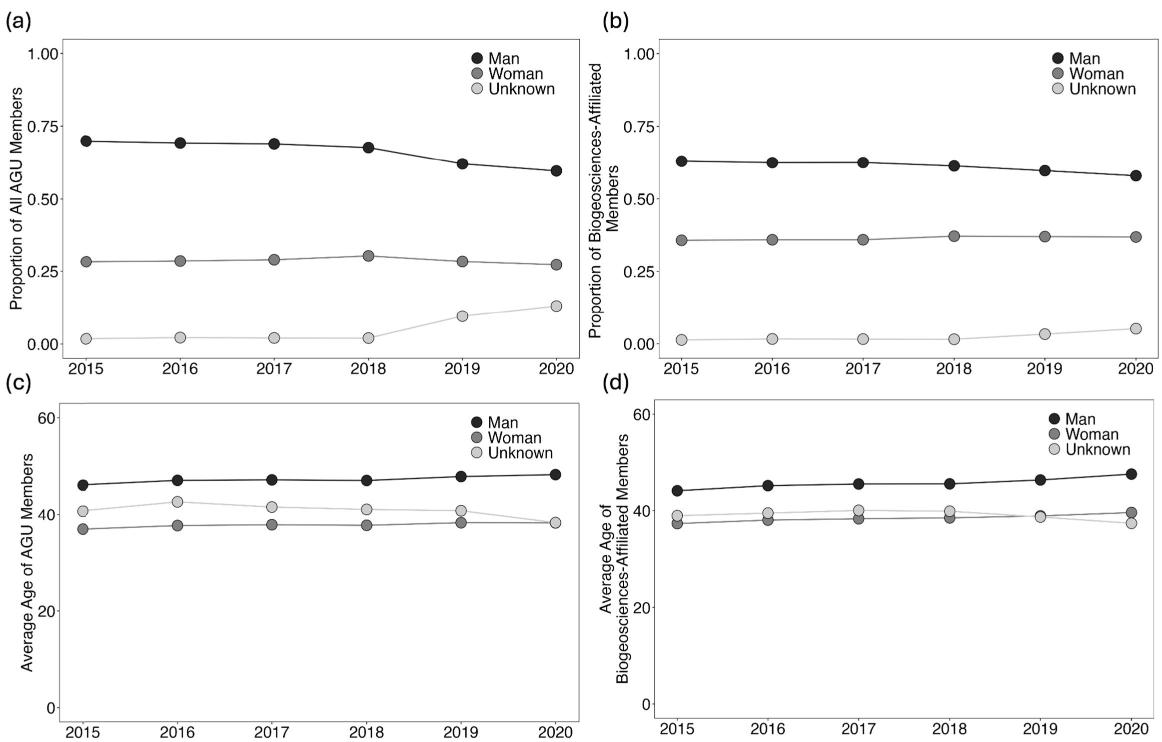

Figure 1. The gender diversity of (a) AGU membership and (b) AGU Biogeosciences section membership from 2015-2020. AGU membership was greatest in 2019 (62,612 members) and has remained disproportionately male (approximately 70%). The average age of (c) AGU members and (d) AGU Biogeoscience members by gender. The “Unknown” category includes the geoscientists who chose “other” as well as those without information.

The biogeosciences as a field are interdisciplinary by definition, and the majority (81.6%) of members listing a secondary affiliation, as compared to the average of 72% of geoscientists at the meeting at large. The top secondary affiliations are Global Environmental Change (28.3%), Atmospheric Sciences (18.6%), and Earth and Planetary Surface Processes (10.3%). The top three primary sections for those who listed Biogeosciences as their secondary affiliation are Hydrology (21.4%), Atmospheric Sciences (17.4%), and Ocean Sciences (17.1%), which are also the three most populous sections within AGU.

In 2020, AGU membership was 59.6% men, 27.3% women,<1% non-binary, and 13.0% unknown, whereas membership with Biogeosciences as first or second affiliation was 58.0% men, 36.9% women, <1% non-binary and 5.2% unknown. The gender diversity of the membership overall and in this section changed slightly over the five years of available data. The proportion of members identifying as men decreased steadily from 70.0% and 63.9% in 2015 across all sections and the Biogeosciences, respectively, while the proportion of members identifying as women did not change (mean±sd=28.6%±1.0% across all sections and 36.4%±1% in the Biogeosciences) (Figure 1a,b). This disparity is likely described by an uptick in members of unknown gender, which peaked 2020. The average age of the AGU membership cohort slightly increased between 2015 (43.4 years) and 2020 (44.9 years). Similarly, the average age of those who choose biogeosciences as their primary or secondary affiliation increased from 41.6 to 44.3 years (mean±sd = 43±0.9) (Figure 1c,d). However, it is worth noting that both at large and within the Biogeosciences section, members who identify as men are older than members who identify as women, on average (Figure 1c,d).

3.2 AGU Fall Meeting Attendance data 2012-2022

The number of attendees to the AGU Fall Meeting varied between 21,388 in 2012 and 27,702 in 2018 over the decade of data, with an average of 24,019 attendees (Figure S2). The number of attendees affiliated with the Biogeosciences section varied similarly over the same time period, between 1,287 in 2012 and 1,801 in 2019 with an average of 1,582 attendees (6.6% of attendees, Figure S2).

Over the entire time period, there was a greater proportion of Biogeoscience members who identified as women (41.4%) scientists as compared to all Fall Meeting attendees (29.4%) overall (Figure 2). The fraction of women, non-binary or gender-queer geoscientists attending the Fall Meeting increased over time, though the fraction of attendees identifying as non-binary or gender-queer remained less than 1% (Figure 2). The age distribution of Fall Meeting attendees shifted over time, with Biogeoscience members being younger, on average than other geoscientists at the meeting: scientists in their 20s and 30s were a greater proportion of conference attendees in 2022 (53.7% of all attendees, 63.5% of biogeoscience members) than 2012 (42.3% all, 52.8% biogeoscience members).

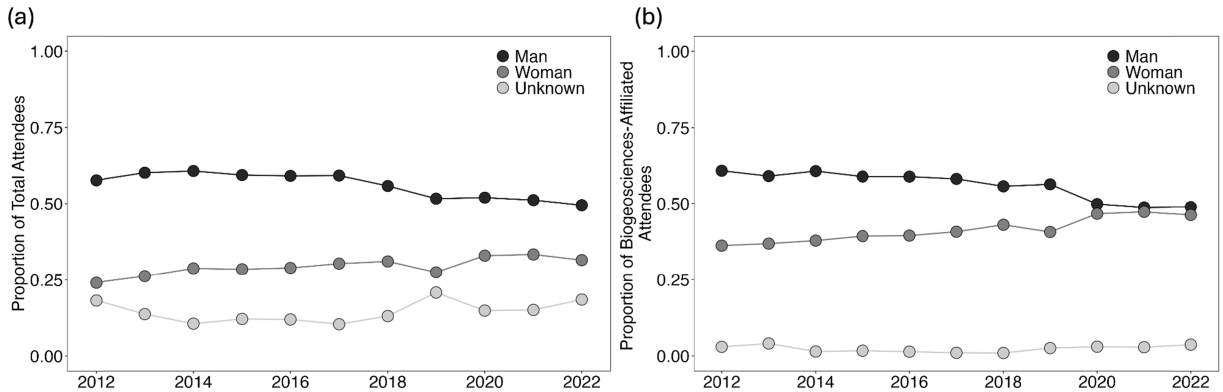

Figure 2. The gender diversity of (a) all AGU Fall Meeting attendees and (b) AGU Biogeosciences member attendees from 2012-2022. AGU Fall Meeting attendance averaged 24,019 attendees and was greatest in 2018 (27,702 attendees), with attendees disproportionately identifying as men. Attendees affiliated with the Biogeosciences section represent 6.6% of the total AGU attendees, and over the last two years (2020-2022) the section is approaching gender parity though less than 1% of attendees identify as non-binary or gender-queer. The “Unknown” category includes the geoscientists who chose “other” as well as those without information.

3.3 Manuscript submission data 2012-2021

The manuscripts involved over 40,000 authors, with 27,919 authors reporting their gender. Of these authors, 73% of these authors identify as men, 27% as women, with less than <1% identifying as non-binary. When examining only first-authors that reported their gender, 64% are men, 36% are women, and <1% non-binary. The proportion of women identifying authors (and first-authors) has increased over time (21.2% in 2012 to 29.9% in 2021 for women authors and 31.5% in 2012 to 40.0% in 2021 for women first-authors); still, the majority of manuscripts submitted to these two journals continue to be authored by men (Figure 3b).

Nearly three-quarters (74.4%) of submissions with self-reported race and ethnicity data had White scientists as first-author and White scientists made up 77% of authors of the submitted manuscripts (Figure 3e,f). First-authors who identify as Asian or Asian-American submitted 15.6%, Hispanic and Latinx submitted 6.8%, with first-authors who identify as Black, African, African-American, Middle Eastern, Indian, Indigenous, Native Hawaiian or Pacific Islander collectively submitted just over 3% of the manuscripts (Figure 3e,f). When examining intersectional identities of authors, White men submitted the largest proportion of manuscripts (43.9%), followed by White women (30.3%), Asian men (11.4%), Asian women (4.3%), Hispanic or Latino (3.6%), and Hispanic or Latina (3.2%), with all other identities submitting less than 1% of manuscripts’ received.

Across the 40,000 authors, 45% had age information. Approximately one-quarter (26%) of manuscripts were submitted by scientists between the age of 30 and 49 (or 58% of the authors with age data). Scientists between the ages of 50 and 69 made up 14% of the author pool (31% of authors with age data). When examining first-author age data, a large majority (88%) of manuscripts were submitted by geoscientists in their 30s.

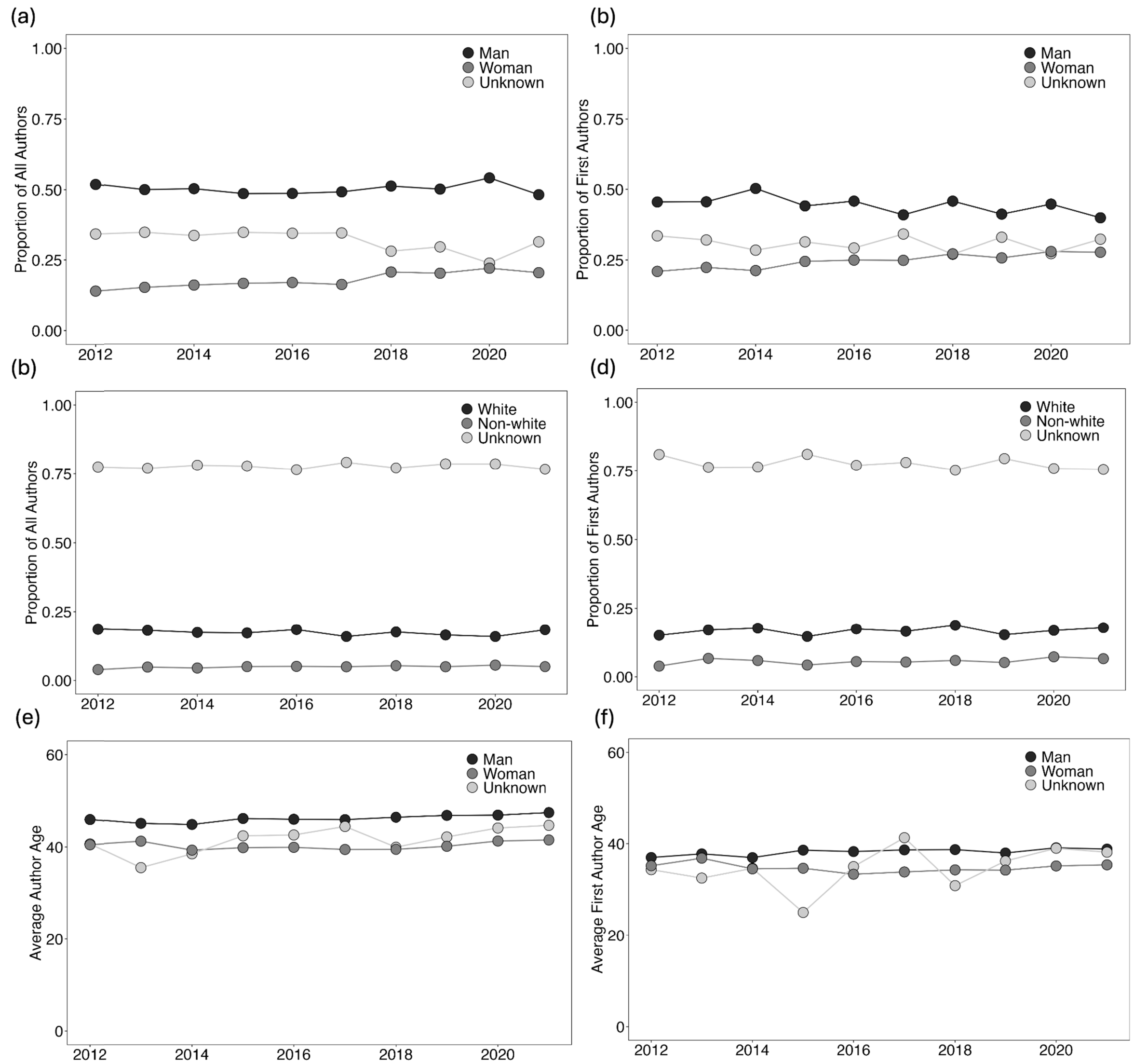

Figure 3. The demographics of geoscientists who submitted a manuscript to *JGR-B* or *GBC* from 2012-2022, including: gender of (a) all authors and (b) first-authors, race and ethnicity of (c) all authors and (d) first-authors, and the average age of (e) all authors and (f) first-authors. The "Unknown" category includes the geoscientists who chose "other" or opt-ed out of the voluntary reporting. Given the large fraction of geoscientists who did not provide race or ethnicity it is difficult to interpret values overtime for each of the groups (Table S1), other than to say that of the geoscientists who report, the majority of them identify as White.

As interdisciplinary scientists, biogeochemists typically work in teams. Single author papers were rare in JGR-B and GBC, making up <1% of submissions; the majority of these (64%) were submitted by men, with an additional 27% submitted by women, and 8% by an author with an unknown gender identity. On average, 6 authors contributed to each paper, with the number of authors varying from 1 to 100. There was no difference in team size between papers with women first-authors versus men first-authors. Papers with more than 20 authors (<1% of submission) were more likely first-authored by a man (58%) than women (24%) or an author with an unknown gender identity (17%). Across the 2388 manuscripts where all authors' genders were identified, 31% had manuscripts with no women nor non-binary scientists, while only 3% of the manuscripts were authored by all-women teams. Of these manuscripts first-authored by men (n=1407), 49% have women and/or non-binary authors included, while 64% of manuscripts first-authored by women or non-binary scientists (n=911) include additional women and/or non-binary scientists as authors.

3.4 Manuscript acceptance data 2012-2021

The average acceptance rate over the decade of submissions to JGR-B and GBC was 47.7%. Of those rejected, ~5% were rejected "and referred" [to another AGU journal] and 43% were rejected with "encouragement to resubmit." All forms of rejection are grouped together in our analyses, as the type of rejection did not vary by reviewer demographics. Based on reviewer response data, few manuscripts were accepted outright (1.3%), with the many of accepted manuscripts first receiving "major revisions" (13.5%) or "minor revisions" (14.1%) recommendations from the reviewers. Given that these values are calculated from individual reviewer responses and individual manuscripts do not get monolithic responses from the review community, we do not expect the values to add to 100%. It does point to the fact that handling editors are more likely to side with reviewers who suggest revision instead of outright rejection. Approximately 2.5% of the papers were withdrawn before review, these were not included in the analyses.

Of the submissions with self-reported gender information, the overall acceptance rate was 53.7%; if data from the GenderAPI are included in this analysis, the overall acceptance rate rises to 56%. Self-reported gender and GenderAPI are combined in all analyses moving forward unless otherwise noted. Acceptance rates were higher for papers with women-first authors (55.8%), than men (52.5%), both are significantly higher than papers led by authors with no gender data provided, i.e. the "unknowns" (34.3%) (Figure 4). The number of submissions by first-authors who identify as non-binary was not enough to reliably calculate an acceptance rate. There was no temporal trend to acceptance rates for any group.

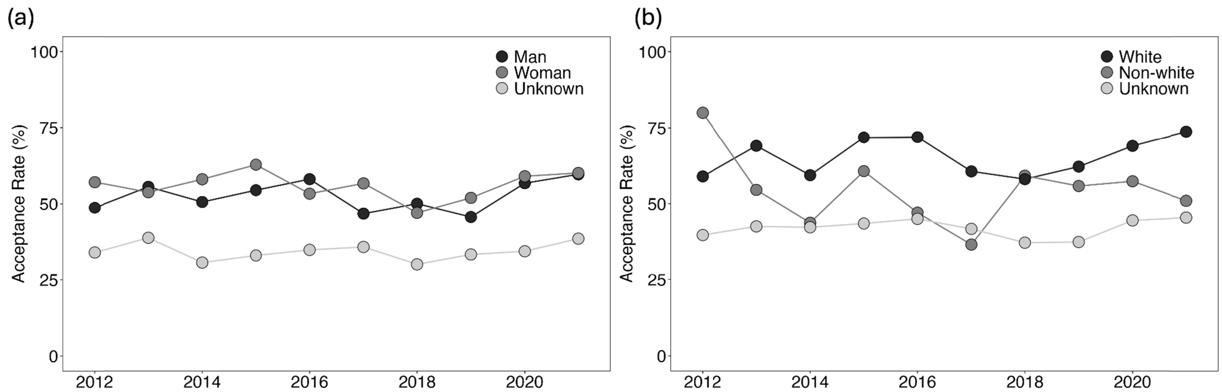

Figure 4. The average acceptance rates for *JGR-B* or *GBC* from 2012-2022 by (a) gender of first-author and by (b) race and ethnicity of first-author. Women first-authors tend to have slightly higher manuscript acceptance rates as compared to men, while White first-authors have generally enjoyed higher acceptance rates than geoscientists of color (b).

Examining the 22% of submissions with self-reported race and ethnicity information, the acceptance rate varied between groups, with White/European first-authors enjoying a 66.9% acceptance rate as compared to a 54.6% and 53.1% acceptance rates for Asian/Asian-American and Hispanic/Latinx first-authors, respectively. The number of papers submitted by geoscientists who self-identified as Black, Middle Eastern, or Indigenous were too few to reliably calculate acceptance rates. The acceptance rate for first-authors without race or ethnicity data was the lowest of all groups at 43.1% (Figure 4). While numbers are too small in most instances to examine acceptance rates across intersectional identities, women of all races and ethnicities tended to have slightly higher acceptance rates than their male counterparts.

Of the 45% of submissions with self-reported age information, the acceptance rate averaged 56.4%. When examining acceptance rate across age and gender of the first-author, women in their 30s (60.1%) and men in their 60s (59.6%) enjoyed the greatest submission success. In general, women had slightly greater acceptance rates than men across age groups (Table S2). It should be noted that several of the gender-age identities did not have enough submissions (n<20) to provide acceptance rates without the possibility of identifying specific papers and authors.

Despite the higher rates of acceptance for manuscripts led by women identifying geoscientists, 46% of published papers in JGR-B and GBC are first-authored by men with over 78% of papers first-authored by White geoscientists. Only 22% of published manuscripts were led by non-White geoscientists, with fewer than 5% authored by non-White, women geoscientists.

3.5 Invited reviewer data 2012-2021

Over 26,000 reviewers were invited to review the 6040 manuscripts between 2012-2021; on average, that is just over 4 reviewers per paper. Over 92% of reviewers provided their gender identity: approximately 64% of invited reviewers are men, 29% identify as women, <1% as non-binary, and 7% are unknown (Figure 5a). Approximately one-third of reviewers (37.6%) provided their race and/or ethnicity. Of the invited reviewers who provided this information, the vast majority of reviewers identify as White (85%), 9.6% of reviewers identifying as Asian or Asian-American, 3.6% as Latino, with scientists who identify as Black, Indigenous, Middle Eastern, and mixed race collectively making up approximately 2% of reviewers (Figure 5b). Reviewers had self-reported age information ~60% of the time: 18% of geoscientists were in their 30s, 20% in their 40s, 13% in their 50s, and 7% in their 60s, when asked to review (Figure 5c, Table S3).

In all age groups, women, non-binary, and gender-queer scientists made up a smaller proportion of invited reviewers than their male identifying counterparts. For example, women in their 40s and 50s made up 10.9% and 4.6% of the reviewer pool, respectively, compared to men of the same ages who made up 22 and 17% of the reviewer pool, respectively (Table S4).

The average number of reviewers asked per manuscript did not appreciably change over the decade examined (mean±sd=5.1±0.26). However, the rate that scientists accepted reviewer assignments did change, with the proportion of invited reviewers accepting assignments generally decreasing from 2012 (44%) to 2021 (37%). The likelihood of scientists agreeing to complete the review did not vary by gender of the reviewer, as men and women agreed to review 39% of the time on average. Scientists of color tended to agree to review more often (46.9%) than their White counterparts (42.7%) with reviewers who identify as Black or African/African-American accepting the most often (54.2% of the time).

Reviewer identity did not appear to have a large effect on reviewer decisions, with similar acceptance rates across reviewer gender, race or ethnicity, and age. Biogeoscientists who identify as women reject manuscripts 23.4% of the time while men reject 25% of manuscripts they reviewed (Table S5), both men, women and non-binary reviewers accepted manuscripts led by women or non-binary scientists more often than those led by men. White biogeoscientists reject 24% of manuscripts they reviewed, while biogeoscientists of color reject 26.5% of the manuscripts they reviewed. However, both White and reviewers of color rejected manuscripts led by authors of color more often than they rejected manuscripts led by White authors. On average, reviewers who rejected manuscripts outright (44.2) were younger than those who accepted them outright (46.4), while those who suggested major and minor revisions were 43.1 and 44.8, respectively.

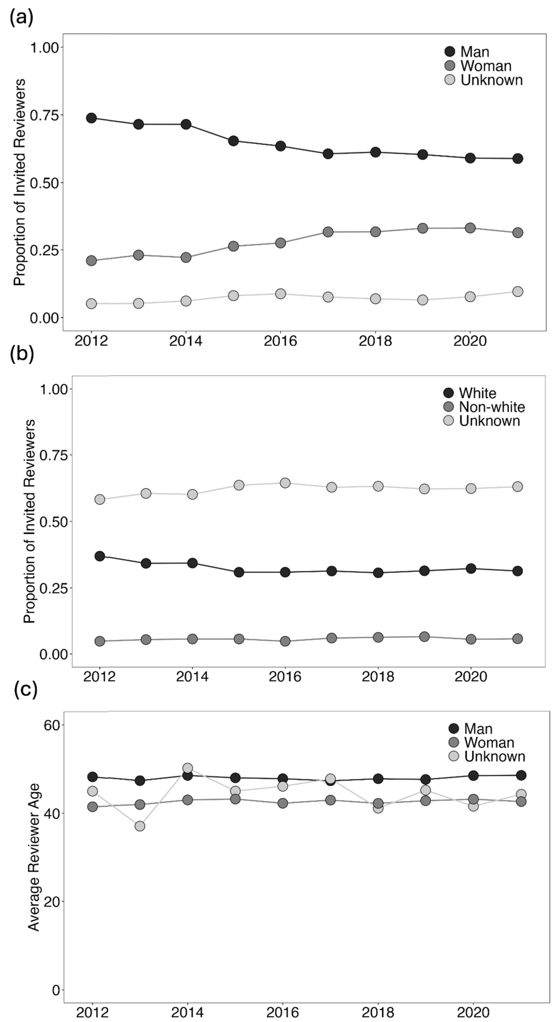

Figure 5. The proportion of invited reviewers by (a) gender, (b) race and ethnicity, and (c) age and gender from 2012-2022.

4 Discussion

Efforts to diversify the geoscience, and the STEM workforce more broadly, have focused on recruitment and visibility, often neglecting the complex but necessary work required to retain and advance individuals from marginalized groups (Allen-Ramdial and Campbell 2014). This focus on recruitment is likely compounded in fields like the geosciences that are "discovery majors," or majors that students rarely come to college to study. People from all backgrounds interested in the earth and ecological sciences as their expertise are needed to address many of our most pressing global challenges, from climate change to air pollution. However, as the AGU data describing milestones in a scientist's career illustrates, access is not granted equally or equitably to all biogeoscientists. Thus, we need systemic changes to institutions that address inequalities, create more inclusive climates, and advance a diversity of scientists (Lerback et al 2022).

4.1 The Hostile Obstacle Course

The proportion of women earning geoscience degrees has increased steadily over the last several decades, from 22.5% in 2005 to 46% 2019 of undergraduate degrees (Gonzales & Keane 2020). Concurrently, the fraction Bachelor's degrees awarded to geoscientists from historically excluded groups increased threefold over the last two decades, to 15.7% (Gonzales & Keane 2020). However these same gains are not seen at the graduate level (Beane et al. 2021), geoscientists from historically excluded groups earning just 6.7% of doctorate degrees in the US with women identifying scientists earning 40% of geoscience PhDs (Gonzales & Keane 2020). As previously mentioned, the proportion of women in academic geoscience positions decreases with seniority, with few in leadership positions (Raganathan et al 2021). Similar patterns are present in the AGU data analyzed, with greater gender parity observed at the earlier milestones (women are ~37% of the Biogeosciences membership and 41% of conference attendance) in a biogeoscientist's path as compared to later milestones: manuscript submission (women first-authors submit 25% of manuscripts), publication (29% of papers accepted by *GBC* or *JGR-B* are first-authored by women), and only 29% of reviewer invites go to women identifying geoscientist. Notably, these later activities are commonly done at the early career stage as one is making a name for themselves in the field and that represents advancement within academia. We note that academia is far from the only path (bio)geoscientist can follow (Bachelor et al. 2021); however, it is the sector we have the most insight into via the literature and our personal experiences. Unfortunately due to lack of data we can not make the same comparisons for biogeoscientists from historically excluded and marginalized groups.

One barrier to diversifying the biogeosciences or any STEM field is the lack of visible representation. A recent poll found that the majority (72%) of people in the U.S. cannot name a living scientist; of those who could name a scientist, only 2% named a woman (Jane Goodall) (Research!America 2021). Scientists are invisible to many and to those who are aware, the majority are White men (500 Women Scientists 2018). In countries where women have reached gender parity, these gender stereotypes are less strongly held, yet the dominant image of a scientist remains a man (Miller et al. 2015). As such, it should not be surprising to find that undergraduate women's scientific identity (Henderson et al. 2022) and her intention to stay in the geosciences, was linked to the Núñeznumber of same-gender role models and mentors in their lives (Hernandez et al. 2018). Núñez and colleagues (2020) concur, discussing the importance of representation in thinking about intersectional identities in the geosciences.

A paid membership to a scientific society does not equate to one feeling included, but it is a metric available to us. As AGU is the largest earth and space scientific organization globally, we can use membership as a measure of the first "step" in the hostile obstacle course that many scientists take. The fraction of scientists identifying as women is greater within the Biogeosciences section (36.9% in 2020) than the overall AGU membership (27.3% in 2020). However, it is difficult to suggest the gender diversity in the Section is appreciably different given the fraction of reported unknowns (5.2% and 13% for the section and society, respectively). These values are similar to other scientific societies with shared membership. In the Geological Society of America (GSA) men make up a slim majority in several career categories, but 70% of professionals (GSA 2023). Almost two-thirds (64.5%) of the European Geophysical Union members (Toth et al. 2021) and 72% of members of the Soil Science Society of America (SSSA), American Society of Agronomy (ASA), and Crop Science Society of America (CSSA) identify as men (Gillispie et al. 2021). In contrast, only 50.8% of the nearly 7800 members of the Ecological Society of America (ESA) identified as men in 2021 (ESA 2021). In all cases, these gender breakdowns reflect a smaller proportion of women identifying scientists in these professional societies as compared to those receiving Bachelor's and Master's degrees from US institutions.

Society membership often accompanies the first time a scientist attends a scientific conference, in part because most societies create financial incentives to do so. However, attending a scientific society's conference typically has significantly more barriers than annual membership. In the case of the AGU Fall Meeting there are large, often out-of-pocket, monetary costs including registration, travel, lodging, and abstract fees (if you plan on presenting) to the scientist (Skiles et al. 2020). On top of this, conferences present accessibility and safety challenges to some members of our community (Joo et al 2022). Comparing AGU's membership (~60K) with attendee data at their largest annual conference (the "annual Fall Meeting" which attracts ~25K attendees) illustrates that a maximum of 40% of members attend annually (i.e., not everyone who attends is a member), with an even smaller average fraction of members associated with the Biogeosciences section (21.5%) attending each year. Comparing the proportion of women attending the annual meeting (41%) in 2019 to the membership (37%) in the Biogeosciences in 2019, suggests that despite additional barriers, women make up greater proportions of conference attendees than would be expected based on membership demographics.

Scientific conferences are important places for scientists to grow their networks, share ideas, and build community. For early career scientists, conferences present unique opportunities to meet fellow scientists, access resources, and grow their networks (McMillion-Brown 2020); however they are also places where one can feel uncomfortable or even unsafe (Raby & Madden 2021). Recognizing this, scientific societies often provide professional development opportunities for early career scientists to network and receive training on topics including funding systems and how to design courses that incorporate research. Scientific societies have also created formal mentoring programs (e.g. AGU's Mentoring365) acknowledging the value of peer mentoring and the different types of support we all need (Glessmer et al 2015, De Janazz & Sullivan 2004, Burt et al. 2023). The characteristics of one's network determines access to information, opportunities, and resources (Hernandez et al. 2023). An analysis of AGU Fall Meeting presentation abstracts from 2014-2018, illustrated that men's and women's networks, as defined by co-authorship, were inherently different. Men had networks that crossed more age groups and contained more international scientists than women, especially in the earlier age cohorts (Hanson et al 2020). These differences in network characteristics likely point to differential access to resources and benefits. A recent study of undergraduate women found that those with larger, more close-knit networks had a greater sense of scientific identity and were more likely to continue onto graduate studies (Hernandez et al. 2023).

Peer reviewed publications are the currency of accomplishment for scientists. Achieving authorship (co-authorship or otherwise) is thus another critical accomplishment in a scientists' career, and one that is non-negotiable at many points in a scientists' life. Submission rates to AGU's two biogeoscience focused journals reveal that men submit significantly more manuscripts than women, a trend common across all AGU journals (Lerback & Hanson 2017). Thus despite the slightly higher acceptance rates for women, the journals continue to be dominated by articles written by men. In the case of *JGR-B* and *GBC*, nearly a third (31%) of the articles published from 2012-2021 had no women geoscientists within the author lists, with women appearing as first author less than 30% of the time. An analysis of images of geoscientists in introductory (physical geology) textbooks reveals that most scientists pictured appear to be White men; with men appearing 2.3x more often than women and White geologists appearing 15x more than scientists of color (Bush & Mattox 2020). In both instances, the outward expression of who a (bio)geoscientist is misaligns with the realities of the workforce in our field. The invitations for peer review for *JGR-B* and *GBC* reflect this misalignment, with 69% of invitations sent to men and 85% to White scientists.

We submit and publish manuscripts to share and collectively build knowledge. The frequency one is cited by others is viewed as a measure of a scientist's impact (e.g., H-index) in their field. However, when citing the literature in our own manuscripts affinity bias and the Matthew effect result in citing work of our colleagues and well known scientists more often (Brainard 2022). Citation metrics thus may more strongly reflect the collective authors' network size than the paper's scientific quality (Lerback et al 2020) or simply be another measure of publishing productivity (Mishra et al. 2018). Previous work examining citation rates of papers published in AGU journals found that citations were lower for papers authored by multi-racial and multi-ethnic US teams, as compared to authorship groups of a single race or ethnicity within the US and papers authored by single-gendered teams and/or authors from one career stage were cited more often (Lerback et al 2020). Thus, despite the efforts to diversify our field, our collective actions continue to reinforce the status-quo.

Why might geoscientists of color and White women submit fewer manuscripts? Often because individuals from historically excluded and marginalized groups spend more time teaching (Gonzales & Keane 2021; Malisch et al 2020), doing institutional service and advising students (Toutkoushian & Bellas 1999, Rideau 2021), and often more of the household duties (Morgan et al 2021). In addition to doing more unpaid service, (bio)geoscientists from excluded groups disproportionately experience negative workplace environments (Marin-Spiotta et al 2023, Primack et al 2023). For example, non-binary (51%), LGBPQ (33%), disabled (26%), women (20%), and geoscientists of color (17%) experienced higher rates of sexual harassment than the average respondent to the survey (14%) in the prior year (Marin-Spiotta et al 2023). This survey data also illustrates that most negative workplace experiences consist of frequent rude and insensitive comments and other microaggressions, often described as “a thousand tiny cuts" which often seem insignificant to outside observers but are shown to be just as destructive to the target’s mental wellbeing (Smith & Griffiths 2022). These negative experiences lead scientists to opt-out of professional events and to consider leaving their institution or the field altogether (Cech & Waidzunas 2021); 50% of Black women and non-binary White geoscience respondents reported considering leaving their position in the year prior (Marin-Spiotta et al 2023).

4.2 The Challenge of Unknowns

As with many similar analyses, most of our conclusions are limited, due to incomplete data. This is especially true with respect to conclusions around race and ethnicity as data coverage is particularly poor for these identity characteristics. In addition, gender data is interpreted from binary sex (male, female) responses, with a third “prefer to not answer” option available and in one-third of instances determined via a commonly used algorithm (GenderAPI). Similarly the race and ethnicity options open to geoscientists are not inclusive of all, the historic variability in reporting this information (number of options and names of options change), and fear of reporting when you are one of a few, leads to low rates of reporting and makes this data difficult, at best, to interpret.

The fraction of geoscientists who self-reported gender, age, and race or ethnicity not only varied by characteristic but also by role within the dataset. For example, there are fewer unknowns for reviewers as compared to authors for *JGR-B* and *GBC* manuscripts, across all demographics. The most likely explanation is that reviewers are more frequently AGU members than authors, thus there is a greater likelihood of demographic information available to be matched. This observation, combined with the dominance of White men in the invited reviewer pool, speaks to the fact that we need to reach beyond our own networks when inviting reviews. The greater fraction of known gender and age information versus race and ethnicity is likely linked to past discriminatory experiences. Studies find that most authors receive inappropriate reviews, though scientists from historically excluded groups are more likely to internalize these messages leading to longer term negative consequences (Silbiger and Stubler 2019). Thus it is likely that race and ethnicity information is preferentially reported by members of majority groups, in an effort to limit exposing oneself to discriminatory actions by making themselves less visible (Settles et al 2019).

5. Moving Forward

Resolving diversity problems in the geosciences must involve approaches beyond outreach and recruitment, we must collectively change the culture of our field. To do this, It is critical for us to acknowledge that the same traditions and practices that welcomed us to the field, could also push others away. As stated by Morris (2021), "ideological changes are required within the geosciences to remove racialized barriers and the psychological violence that prevents access and opportunities for full participation of BIPOC+ in the academy and other careers." Codes of Conduct and Field Safety plans provide guidance and frameworks for accountability to the community and several geoscientist-led efforts provide resources for making your classroom, your laboratory, your team meetings, more welcoming, inclusive, and accessible.

In creating their Ethical Code of Conduct in 2017, AGU became the first scientific society to acknowledge bullying, harassment, and discrimination as scientific misconduct (McPhaden et al. 2017). In expanding the definition of scientific misconduct beyond the falsification of data and plagiarism to include the treatment of people, AGU implicitly recognized the harm these actions have on the understanding of our planet, on the creation of knowledge. Since then, scientists need to agree to the Ethical Code of Conduct to attend their meetings, a critical step towards making the conference experience more inclusive (Favaro et al 2016). AGU has also created its Safe AGU program, training conference staff on how to respond to incidents of harassment and bullying and having them present, visible, and available during meetings and all honorees are asked about current and past conduct, resulting in the rescinding of at least one award (Reardon 2018). The practice of requiring attendees to sign a Code of Conduct is now fairly common at many scientific conferences and meetings biogeoscientists attend, however the specifics vary.

Field work is often an assumed part of a (bio)geoscientists' work. The increased risk of assault, harassment, and bullying associated with remote field work, common in many fields within the ecological and geological sciences, is well documented (e.g., Willenbring 2018, Jha 2021). In many instances, scientists do not know how, or who, to report to (Clancy et al 2014), with early career scientists having less knowledge of the processes than those with more experience

(Primack et al 2023). In response, field safety plans are becoming more common with numerous resources available in the literature that address both general (McGill et al 2021) and specific field safety considerations for marginalized members of our community (Rudzki et al 2022), for LGBTQ+ scientists (Coon et al 2022, Olcott & Downen 2020), for Black, Indigenous and geoscientists of color (Anadu et al 2020). The evidence is such that the US National Science Foundation has started a pilot program requiring Field Safety Plans (NSF 23-071) as part of proposals for several programs in the Biological Sciences and Geoscience Directorates.

While there is no information on scientists' disabilities in the data provided to us, we know the cultural assumptions and educational requirements around field work are exclusionary (Demery & Pipkin 2021, Lawrence 2021). During the COVID-19 pandemic many academic departments were forced to change field requirements and others have shifted their requirements, recognizing their inherent ableism (Powell 2021; Marshall and Thatcher 2019). Conferences, including the AGU Fall Meeting, moved to online and hybrid environments providing opportunities to improve access to some scientists with disabilities and increase inclusivity for scientists from multiple marginalized groups (Sarabipour, 2020; McMillion-Brown 2021, Raby and Madden 2021, Skiles et al 2020).

Culture change across the geosciences requires a collective effort. Thanks to numerous members of the geoscience and ecological science communities, many of whom identify as members of historically excluded and marginalized groups, there are resources available to create more inclusive spaces. Ali and Presad (2022) provide several examples of how institutions can meaningfully engage in activities to create accessible, inclusive, just, and equitable programs from reviewing outward facing recruitment materials to changing promotion criteria to include DEI work. Cooperdock and colleagues (2021) suggest actions that individual researchers can take in their own laboratories, classrooms, and field settings, including creating codes of conduct, discussing DEI issues on a regular basis, understanding one's own positionality, and adopting anti-oppressive lab guidelines (e.g. Anti-Racist Lab Rules;, Chaudhary & Berhe 2020). Acknowledging that the way we conduct research affects more than just the members of our team, but also the impact of our work, Harris and colleagues (2021) challenge fellow geoscientists to do place-based, community-based, interdisciplinary research and Jones (2021) suggests geoscientists team up with local environmental organizations, inherently expanding what geoscience research can be. We encourage our colleagues to purposefully engage with these materials, have open, honest, and sometimes uncomfortable discussions with your colleagues, and importantly act to implement change in your space.

As the largest membership of earth and space scientists, AGU is a role model and we hope that their leadership on several of these issues will encourage other scientific societies as well as institutions to take similar measures. As a role model, like other highly regarded institutions, they have a "duty to demonstrate best practices -- not only in research & education -- but also in being socially responsible" (Ali & Presad 2022). While progress was made in 2022 to diversify the reviewer and editorial pool (Huntzinger et al 2023), AGU editorial boards need to continue to work to make their journals more inclusive and accessible. The addition of open-access journals and uptick in publication of diversity, equity, inclusivity and accessibility research across the AGU journals are important, positive steps forward. We welcome the specific steps discussed in the *JGR-B* editors' update (Xenopoulos et al 2023) and we ask handling editors to take a more active role in ensuring reviews are respectful and when they are not, providing written statements sent to both authors and reviewers stating as much. These statements will not erase the harm of disrespectful and mean-spirited reviews on the authors (Silbiger and Stubler 2019), however acknowledgement can help minimize their psychological impact (Latane and Rodin 1969) and will signal the values of the journal. To enact this *culture change* requires leadership at all levels, for everyone to act, "We must shift our focus from performing diversity to enacting inclusive change" (Raji & Ali 2021).

Acknowledgements

The authors would like to thank Paige Wooden for her assistance with accessing AGU data and the editors for the invitation to submit this work. Many thanks also go to their friends and pets (Ruthie B Ginsburg, Breyer, Dean Martin, Dolly Parton, Tofu, De La Tuna, Kingsley, Louis Pasteur) who provided support throughout the paper drama. MAW was also supported by NSF OIA 2019603. This work was partially conducted at the Jet Propulsion Laboratory, California Institute of Technology, with institutional support to ELC.

Open Research

De-identified and composited data as allowed per the AGU confidentiality statement is available via Hydroshare: http://www.hydroshare.org/resource/7ff2cac594194c7f8fb9d3816c84e142. Prior to publication data will be published, and receive a DOI.

References

500 Women Scientists (2018). Bill Nye Does Not Speak For Us and He Does Not Speak for Science, *Scientific American*, available here: https://blogs.scientificamerican.com/observations/bill-nye-does-not-speak-for-us-and-he-does-not-speak-for-science/

Ali, H.N. and Prasad, M. (2021). On ranking and representation in the geosciences. *AGU Advances*, *2*(4), p.e2021AV000474.

Allen-Ramdial, S.A.A. and Campbell, A.G. (2014). Reimagining the pipeline: Advancing STEM diversity, persistence, and success. *BioScience*, *64*(7), pp.612-618.

American Geophysical Union. Mentoring365 project, access here: https://mentoring365.chronus.com/

American Geophysical Union. SafeAGU program, access here: https://www.agu.org/Learn-About-AGU/About-AGU/Ethics/SafeAGU

Anadu, J., Ali, H. and Jackson, C. (2020). Ten steps to protect BIPOC scholars in the field. *Eos*, *101*(10.1029).

Bailey, K., Morales, N. and Newberry III, M. (2020). Inclusive conservation requires amplifying experiences of diverse scientists. *Nature Ecology & Evolution*, *4*(10), pp.1294-1295.

Batchelor, R. L., H. Ali, K. G. Gardner-Vandy, A. U. Gold, J. A. MacKinnon, and P. M. Asher (2021). Reimagining STEM workforce development as a braided river, *Eos*, 102, doi: 10.1029/2021EO157277.

Beane, R.J., Baer, E.M., Lockwood, R., Macdonald, R.H., McDaris, J.R., Morris, V.R., Villalobos, I.J. & White, L.D. (2021). Uneven increases in racial diversity of US geoscience undergraduates. *Communications Earth & Environment*, *2*(1), p.126.

Bush, P. & S.Mattox (2020). Decadal review: How gender and race of geoscientists are portrayed in physical geology textbooks, *Journal of Geoscience Education*, 68:1, 2-7, DOI: 10.1080/10899995.2019.1621715

Berhe, A.A., Barnes, R.T., Hastings, M.G., Mattheis, A., Schneider, B., Williams, B.M. & Marín-Spiotta, E. (2022). Scientists from historically excluded groups face a hostile obstacle course. *Nature Geoscience*, *15*(1), pp.2-4.

Bernard, R. E., & Cooperdock, E. H. G. (2018). No progress on diversity in 40 years. *Nature Geoscience*, 11(5), 292–295. doi: 10.1038/s41561-018-0116-6.

Brainard, J., (2022). Reviewers award higher marks when a paper's author is famous. *Science*, *13*.

Burt, M. A., R. T. Barnes, S. Schanz, S. Clinton, &E. V. Fischer (2023). Mentorship builds inclusivity and belonging in the geosciences, *Eos*, 104, doi: 10.1029/2023EO230020.

Cech, E.A. and Waidzunas, T.J. (2021). Systemic inequalities for LGBTQ professionals in STEM. *Science advances*, *7*(3), p.eabe0933.

Chaudhary, V.B. and A.A. Berhe (2020). Ten simple rules for building an antiracist lab. *PLoS Computational Biology,* 16(10): e1008210. doi: 10.1371/journal.pcbi.1008210

Clancy, K.B., Cortina, L.M. and Kirkland, A.R. (2020), Use science to stop sexual harassment in higher education. *Proceedings of the National Academy of Sciences*, *117*(37), pp.22614-22618.

Clancy, K.B., Nelson, R.G., Rutherford, J.N. and Hinde, K. (2014), Survey of academic field experiences (SAFE): Trainees report harassment and assault. *PloS one*, *9*(7), p.e102172.

Coon, J.J., Alexander, N., Smith, E.M., Spellman, M., Klimasmith, I.M., Allen-Custodio, L.T., Clarkberg, T., Knutson, D., Fountain, K. and Rivera, M. (2022). Best practices for LGBTQ+ inclusion during ecological fieldwork: Considering safety, cis/heteronormativity, and structural barriers. doi: 10.1111/1365-2664.14339

Cooperdock, E. H. G., Chen, C. Y., Guevara, V. E., & Metcalf, J. R. (2021), Counteracting systemic bias in the lab, field, and classroom. *AGU Advances*, 2, e2020AV000353. doi: 10.1029/2020AV000353

De Janasz, S.C. and Sullivan, S.E. (2004). Multiple mentoring in academe: Developing the professorial network. *Journal of vocational behavior*, *64*(2), pp.263-283.

Demery, AJ.C., Pipkin, M.A. (2021) Safe fieldwork strategies for at-risk individuals, their supervisors and institutions. *Nat Ecol Evol* 5, 5–9 . doi: 10.1038/s41559-020-01328-5

Dutt, K. (2020). Race and racism in the geosciences. *Nature Geoscience*. doi: 10.1038/s41561-019-0519-z.

ESA (2021) Ecological Society of America Annual Report, access here: https://www.esa.org/2021/

Favaro, B., Oester, S., Cigliano, J.A., Cornick, L.A., Hind, E.J., Parsons, E.C.M. and Woodbury, T.J. (2016). Your science conference should have a code of conduct. *Frontiers in Marine Science*, *3*, p.103.

Galloway, J.N., Bleeker, A. and Erisman, J.W. (2021). The human creation and use of reactive nitrogen: a global and regional perspective. *Annual Review of Environment and Resources*, *46*, pp.255-288.

Gillispie, E., S. Chapman, & B. Jacques. (2021). ASA, CSSA, SSSA Diversity, Equity, and Inclusion Survey Report, access at: https://www.soils.org/files/DEI/dei-survey-summary-report-06252021.pdf

Gleßmer, M., Adams, A., Hastings, M. and Barnes, R. (2015). Taking Ownership of Your Mentoring: Lessons Learned from Participating in the Earth Science Women's Network. The Graduate School Press.

GSA (2023) GSA Membership Demographics, access at: https://rock.geosociety.org/net/documents/gsa/about/MbrDemographics.pdf

Gonzales, L. & Keane, C. (2020). Diversity in the Geosciences. American Geosciences Institute. Data Brief 2020-023

Gonzales, L., & Keane, C. (2021). Academic activities by gender and faculty rank during the pandemic. Geoscience currents. American Geosciences Institute. Data Brief 2021-019.

Hanson, B., Wooden, P. and Lerback, J. (2020). Age, gender, and international author networks in the Earth and space sciences: implications for addressing implicit bias. *Earth and Space Science*, *7*(5), p.e2019EA000930.

Harris, L.A., Garza, C., Hatch, M., Parrish, J., Posselt, J., Alvarez Rosario, J.P., Davidson, E., Eckert, G., Wilson Grimes, K., Garcia, J.E. and Haacker, R. (2021). Equitable Exchange: A framework for diversity and inclusion in the geosciences. *AGU Advances*, 2(2), p.e2020AV000359.

Henderson, H.L., Bloodhart, B., Adams, A.S., Barnes, R.T., Burt, M., Clinton, S., Godfrey, E., Pollack, I., Fischer, E.V. and Hernandez, P.R. (2022). Seeking congruity for communal and agentic goals: a longitudinal examination of US college women's persistence in STEM. *Social Psychology of Education*, *25*(2-3), pp.649-674.

Hernandez, P.R., Bloodhart, B., Adams, A.S., Barnes, R.T., Burt, M., Clinton, S.M., Du, W., Godfrey, E., Henderson, H., Pollack, I.B., and Fischer, E.V. (2018). Role modeling is a viable retention strategy for undergraduate women in the geosciences. *Geosphere*, v. 14, no. 6, p. 2585–2593, doi: 10.1130/GES01659.1.

Hernandez, P.R., Patterson, M., Nyanamba, J.M., Bloodhart, B., Adams, A.S., Barnes, R., Burt, M., Clinton, S.M., Pollack, I.B. and Fischer, E.V. (2023). Webs of Science: Mentor Networks Influence Women's Integration into STEM Fields. *Front Ecol Environ* 2023; doi:10.1002/fee.2666

Hofstra, B., Kulkarni, V. V., Munoz-Najar Galvez, S., He, B., Jurafsky, D., & McFarland, D. A. (2020). The diversity-innovation paradox in science. *Proceedings of the National Academy of Sciences*, 117(17), 9284–9291. doi: 10.1073/pnas.1915378117

Huntzinger, D., Bond-Lamberty, B., Desai, A. R., & Xenopoulos, M. A. (2023). Shining a spotlight on our 2022 reviewers for JGR: Biogeosciences. *Journal of Geophysical Research: Biogeosciences*, 128(4), e2023JG007516. doi: 10.1029/2023JG007516

Jha, Nishita (2021). Welcome to the Jungle: The Smithsonian's #MeToo Moment, BuzzFeed.News, published Dec 9, 2021, available: https://www.buzzfeednews.com/article/nishitajha/smithsonian-tropical-research-institute-metoo

Joo, R., Sánchez-Tapia, A., Mortara, S., Saibene, Y.B., Turner, H., Peter, D.H., Morandeira, N.S., Bannert, M., Almazrouq, B., Hare, E. and Ación, L. (2022). Ten simple rules to host an inclusive conference. *PLoS computational biology*, *18*(7), p.e1010164.

Jones, J.C. (2021). We need accomplices, not allies in the fight for an equitable geoscience. *AGU Advances*, *2*(3), p.e2021AV000482.

Lawrence, A (2021). Between a rock and a workplace. *Nature Geoscience*. 14, 454–455 (2021). doi: /10.1038/s41561-021-00775-4

Latané, B. and Rodin, J. (1969). A lady in distress: Inhibiting effects of friends and strangers on bystander intervention. *Journal of Experimental Social Psychology*, *5*(2), pp.189-202.

Lerback, J. and Hanson, B. (2017). Journals invite too few women to referee. *Nature*, *541*(7638), pp.455-457.

Lerback, J.C., Hanson, B. and Wooden, P. (2020). Association between author diversity and acceptance rates and citations in peer-reviewed earth science manuscripts. *Earth and Space Science*, *7*(5), p.e2019EA000946.

Lerback, J.C., Holt, M.M., St. Pierre, G.A.E., Putman, A., Tulley-Cordova, C.L., Smith, W.A., Caughman, L. and Alvarez, S. (2022). Community voices: Achieving real diversity in STEM requires the ability to transform institutions. *Nature Communications*, *13*(1), p.1684

Malisch, J.L., Harris, B.N., Sherrer, S.M., Lewis, K.A., Shepherd, S.L., McCarthy, P.C., Spott, J.L., Karam, E.P., Moustaid-Moussa, N., Calarco, J.M. and Ramalingam, L. (2020). In the wake of COVID-19, academia needs new solutions to ensure gender equity. *Proceedings of the National Academy of Sciences*, *117*(27), pp.15378-15381.

Marín-Spiotta, E., Barnes, R.T., Berhe, A.A., Hastings, M.G., Mattheis, A., Schneider, B. and Williams, B.M. (2020). Hostile climates are barriers to diversifying the geosciences. *Advances in Geosciences*, *53*, pp.117-127.

Marin-Spiotta, E., Diaz-Vallejo, E.J., Barnes, R.T., Mattheis, A., Schneider, B., Berhe, A.A., Hastings, M.G., Williams, B.M. and Magley, V. (2023). Exclusionary behaviors reinforce historical biases and contribute to loss of talent in the earth sciences. *Earth's Future*, *11*(3), p.e2022EF002912.

Marshall, A.M. and Thatcher, S. (2019). Creating spaces for geoscientists with disabilities to thrive. *Eos*, *100*.

McGill, B.M., Foster, M.J., Pruitt, A.N., Thomas, S.G., Arsenault, E.R., Hanschu, J., Wahwahsuck, K., Cortez, E., Zarek, K., Loecke, T.D. and Burgin, A.J. (2021). You are welcome here: A practical guide to diversity, equity, and inclusion for undergraduates embarking on an ecological research experience. *Ecology and Evolution*, *11*(8), pp.3636-3645

McMillon-Brown, L. (2021). Implementing diversity, equity and inclusion efforts at conferences. *Nature Energy*, *6*(11), pp.1000-1002.

McPhaden, M. J.,Gundersen, L., and Williams, B. M. (2017), AGU revises its integrity and ethics policy, *Eos*, 98, doi: 10.1029/2017EO082469

Miller, D. I., Eagly, A. H., & Linn, M. C. (2015). Women's representation in science predicts national gender-science stereotypes: Evidence from 66 nations. *Journal of Educational Psychology*, 107(3), 631–644. doi: 10.1037/edu0000005

Mishra, S., Fegley, B.D., Diesner, J. and Torvik, V.I. (2018). Self-citation is the hallmark of productive authors, of any gender. *PloS one*, *13*(9), p.e0195773.

Morgan, A.C., Way, S.F., Hoefer, M.J., Larremore, D.B., Galesic, M. and Clauset, A. (2021). The unequal impact of parenthood in academia. *Science Advances*, *7*(9), p.eabd1996.

Morris, V., & Washington, T. (2017). The role of professional societies in STEM diversity. *Journal of the National Technical Association*, 87(1), 22–31.

Morris, V.R. (2021). Combating racism in the geosciences: Reflections from a black professor. *AGU Advances*, *2*(1), p.e2020AV000358.

Morgan, A.C., Way, S.F., Hoefer, M.J., Larremore, D.B., Galesic, M. and Clauset, A. (2021). The unequal impact of parenthood in academia. *Science Advances*, *7*(9), p.eabd1996.

National Academies of Sciences, Engineering, and Medicine (2018). Sexual harassment of women: climate, culture, and consequences in academic sciences, engineering, and medicine. access here: https://nap.nationalacademies.org/resource/24994/faq/

Nielsen, M.W., S. Alegria, L. Börjeson, H. Etzkowitz, H. J. Falk-Krzesinski, A. Joshi, E. Leahey, L. SmithDoerr, A. W. Woolley, and L. Schiebinger (2017). Gender diversity leads to better science. *Proceedings of the National Academy of Sciences of the United States of America* 114(8):17401742. DOI: 10.1073/pnas.1700616114.

Núñez, A.M., Rivera, J. and Hallmark, T. (2020). Applying an intersectionality lens to expand equity in the geosciences. *Journal of Geoscience Education*, *68*(2), pp.97-114.

Olcott, A. N. & Downen, M. R. (2020) The Challenges of Fieldwork for LGBTQ+ Geoscientists. Eos 101,. https://eos.org/features/the-challenges-of-fieldwork-for-lgbtq-geoscientists

Powell, K. (2021). Academia's ableist mindset needs to change. *Nature*, *598*(7882), pp.693-695.

Primack, R.B., Miller, T.K., Terry, C., Marín-Spiotta, E., Templer, P.H., Berhe, A.A., Diaz Vallejo, E.J., Hastings, M.G., Magley, V.J., Mattheis, A., Schneider, B.B., and Barnes, R.T. (2023). Historically excluded groups in ecology are undervalued and poorly treated. *Frontiers in Ecology and the Environment*. doi:

Puritty, C., Strickland, L.R., Alia, E., Blonder, B., Klein, E., Kohl, M.T., McGee, E., Quintana, M., Ridley, R.E., Tellman, B. and Gerber, L.R. (2017). Without inclusion, diversity initiatives may not be enough. *Science*, *357*(6356), pp.1101-1102.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Raby, C.L. and Madden, J.R. (2021). Moving academic conferences online: Aids and barriers to delegate participation. *Ecology and Evolution*, *11*(8), pp.3646-3655.

Raji, M., & Ali, H. (2021). Where are the Black geoscientists? Geoscientist. access at: https://geoscientist.online/sections/features/whereare-the-black-geoscientists/

Ranganathan, M., Lalk, E., Freese, L.M., Freilich, M. A., Wilcots, J., Duffy, M.L., & Shivamoggi, R. (2021). Trends in the representation of women among US geoscience faculty from 1999 to 2020: The long road toward gender parity. *AGU Advances*, 2, e2021AV000436. doi: 10.1029/2021AV000436

Reardon, S (2018). Geoscience society rescinds award to top seismologist after ethics investigation, *Nature*, doi: 10.1038/d41586-018-05171-4

Research!America (2021), Survey: Most Americans Cannot Name a Living Scientist or a Research Institution. access at: https://www.researchamerica.org/blog/survey-most-americans-cannot-name-a-living-scientist-or-a-research-institution/

Rideau, R. (2021). “We're just not acknowledged”: An examination of the identity taxation of full-time non-tenure-track Women of Color faculty members. *Journal of Diversity in Higher Education*, *14*(2), p.161.

Rudzki, E.N., Kuebbing, S.E., Clark, D.R., Gharaibeh, B., Janecka, M.J., Kramp, R., Kohl, K.D., Mastalski, T., Ohmer, M.E., Turcotte, M.M. and Richards-Zawacki, C.L. (2022). A guide for developing a field research safety manual that explicitly considers risks for marginalized identities in the sciences. *Methods in Ecology and Evolution*, *13*(11), pp.2318-2330.

Sanin, J.R. (2020). “I don’t belong here”: Understanding hostile spaces. In *Me Too Political Science* (pp. 112-121). Routledge.

Sarabipour, S. (2020). Virtual conferences raise standards for accessibility and interactions. *Elife*, *9*, p.e62668.

Sarraju, A., Ngo, S. and Rodriguez, F. (2023). The leaky pipeline of diverse race and ethnicity representation in academic science and technology training in the United States, 2003–2019. *PLoS one*, *18*(4), p.e0284945.

Sebo P. (2021). Performance of gender detection tools: a comparative study of name-to-gender inference services. *J Med Libr Assoc*. 109(3):414-421. doi: 10.5195/jmla.2021.1185.

Settles, I.H., Buchanan, N.T. and Dotson, K. (2019). Scrutinized but not recognized:(In) visibility and hypervisibility experiences of faculty of color. *Journal of Vocational Behavior*, *113*, pp.62-74.

Silbiger, N.J. and Stubler, A.D. (2019). Unprofessional peer reviews disproportionately harm underrepresented groups in STEM. *PeerJ*, *7*, p.e8247.

Skiles, M., Yang, E., Reshef, O., Muñoz, D., Cintron, D., Lind, M.L., Rush, A., Armani, A., Faust, K. and Kumar, M. (2020). Beyond the carbon footprint: Virtual conferences increase diversity, equity, and inclusion. access at: https://www.researchsquare.com/article/rs-106316/v1

Smith, I.A. and Griffiths, A. (2022). Microaggressions, everyday discrimination, workplace incivilities, and other subtle slights at work: A meta-synthesis. Human Resource Development Review, 21(3), pp.275-299.

Tajmel, T. (2019) Pathways, intersections and leaky pipelines: the cognitive function of metaphors for research on STEM careers. *Cult Stud of Sci Educ* 14, 1105–1113. doi: 10.1007/s11422-018-9893-x

Toth, E., Jesus-Rydin, C. and Montanari, A., (2020). *Gender and career-stage distribution at EGU General Assemblies* (No. EGU2020-21785). Copernicus Meetings.

Toutkoushian, R.K. and Bellas, M.L. (1999). Faculty time allocations and research productivity: Gender, race and family effects. *The review of higher education*, *22*(4), pp.367-390.

Trisos, C.H., Auerbach, J. and Katti, M. (2021). Decoloniality and anti-oppressive practices for a more ethical ecology. *Nature Ecology & Evolution*, *5*(9), pp.1205-1212.

Vladimir, V. and McMenamin, A.S., (1926). *The Biosphere.*

Willenbring, J. (2018). Sending out the bat-signal. Speaking of Geoscience. access at: https://speakingofgeoscience.org/2018/10/29/sending-out-the-bat-signal/

Wooden, P., & Hanson, B. (2022). Effects of the COVID-19 pandemic on authors and reviewers of American Geophysical Union Journals. *Earth and Space Science*, 9(2). e2021EA002050. doi: 10.1029/2021EA002050

Wynn-Grant, R. (2019). On reporting scientific and racial history. *Science*, *365*(6459), pp.1256-1257.

Xenopoulos, M. A., Desai, A., Huntzinger, D., Bastos, A., Fawcett, S., Sahagian, D., et al. (2022). Statement of contribution to diversity, equity, and inclusion for JGR: Biogeosciences. *Journal of Geophysical Research: Biogeosciences*, 127(2), e2022JG006791. doi: 10.1029/2022JG006791

Xenopoulos, M. A., Bond-Lamberty, B., Huntzinger, D., Desai, A. R., Feng, X., Hammond, W. M., et al. (2023). Update on our action plan for equity, inclusion, and diversity in publishing at JGR: Biogeosciences. *Journal of Geophysical Research: Biogeosciences*, 128, e2023JG007712. doi: 10.1029/2023JG007712

Ysseldyk, R., Greenaway, K.H., Hassinger, E., Zutrauen, S., Lintz, J., Bhatia, M.P., Frye, M., Starkenburg, E. and Tai, V., (2019). A leak in the academic pipeline: Identity and health among postdoctoral women. *Frontiers in psychology*, *10*, p.1297.

Zambrana, R.E., (2019). *Toxic ivory towers: The consequences of work stress on underrepresented minority faculty*. Rutgers University Press.