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Underrepresented faculty play a disproportionate role in advancing diversity and inclusion

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A diverse and inclusive scientific community is more productive, innovative and impactful, yet ecology and evolutionary biology continues to be dominated by white male faculty. We quantify faculty engagement in activities related to diversity and inclusion and identify factors that either facilitate or hinder participation. Through a nationwide survey, we show that faculty with underrepresented identities disproportionally engage in diversity and inclusion activities, yet such engagement was not considered important for tenure. Faculty perceived time and funding as major limitations, which suggests that institutions should reallocate resources and reconsider how faculty are evaluated to promote shared responsibility in advancing diversity and inclusion.

Increasing the diversity of scientists is a priority for many institutions and professional societies[1]. The benefits of a diverse and inclusive scientific community are well documented. Diverse teams are more productive and innovative[2–5], and more fully harness human capital by including ideas from different segments of the population[6]. In an era where trust in science has waned, science is more likely to be relevant to society if practitioners reflect the diversity of the broader community[7]. Diverse role models are critical to recruiting the next generation of scientists and dispelling the stereotype of science, technology, engineering and mathematics (STEM) professionals as older, white men[8]. Furthermore, it is arguably a moral imperative to expand opportunities and dismantle barriers for people from diverse and marginalized backgrounds to engage in science[9].

Nevertheless, major disparities in gender, ethnicity and other dimensions of a diverse workforce persist in various STEM fields[10–12], including ecology[13–15]. These disparities have been variously attributed to implicit bias[16,17], gender-based family responsibilities[18], family pressure on minority students to pursue other careers[19,20] and low self-efficacy[21]—or imposter syndrome. Disparities may also persist because of an academic culture that provides historically marginalized groups with limited support and opportunities[22].

Faculty play strong roles in the hiring, training and mentoring of the next generation of scientists. As such, they have tremendous potential to advance diversity and inclusion at their institutions and in their fields of enquiry[7,23]. However, the degree to which faculty actively engage in advancing diversity and inclusion, and the characteristics of faculty who engage, are virtually unknown. Furthermore, faculty may feel committed to diversity-related initiatives and actions but face substantive barriers to engagement[23]. Identifying barriers and strategies to overcome these could catalyse much-needed changes in recruitment and retention.

To overcome current disparities and ensure that science reflects and is relevant to society, it is critical to understand what factors contribute to or inhibit faculty engagement in diversity and inclusion activities. To achieve this objective, we ask: (1) how do ecology and evolutionary biology faculty value and participate in activities related to diversity and inclusion? (2) What characteristics of faculty are associated with engagement in these activities? (3) What do faculty perceive as the key motivations and barriers for participation? (4) What resources or approaches are most likely to reduce these barriers and enhance faculty engagement in diversity and inclusion?

To address these questions, we conducted an online survey of faculty associated with ecology and evolutionary biology doctoral programmes in the United States. Of the 469 survey respondents, 87.6% identified as white/Caucasian, 51.6% as male and 22.0% as the first generation in their families to attend college (Supplementary Table 1). Most respondents were full professors at their institution (50.3%), while fewer were associate (26.9%) or assistant professors (22.8%). Most respondents reported engaging in diversity and inclusion activities (91.7%) and felt that their institutions valued these activities. Nevertheless, the majority of faculty (71.7%) also felt that engaging in these activities was relatively unimportant for tenure decisions, and many (50.5%) felt that they valued diversity and inclusion more than their peers (Supplementary Fig. 1).

Non-white, non-male and first-generation faculty, as well as those in associate or full professor positions, were consistently more likely to engage in diversity and inclusion activities (Fig. 1 and Supplementary Tables 2 and 3). Non-white faculty recruited minority faculty, engaged in outreach to diverse K-12 schools and served on diversity committees more frequently than non-Hispanic white faculty. First-generation faculty engaged more frequently in recruitment of minority faculty and undergraduate students and were more likely to author diversity-focused, peer-reviewed publications. Non-male faculty organized and attended diversity workshops more frequently than male faculty. As the single exception to this trend, non-male faculty were less likely to recruit minority undergraduate students compared with male faculty. Faculty in tenured positions were also more likely to engage in a subset of diversity and inclusion activities, such as the recruitment of minority faculty and serving on diversity committees.

Of those faculty that actively engaged, more than half strongly agreed that they were motivated by the desire to train diverse leaders as role models, increase scientific literacy among diverse groups, improve research and teaching in their fields and because they felt morally obligated (Supplementary Fig. 2). Fewer faculty

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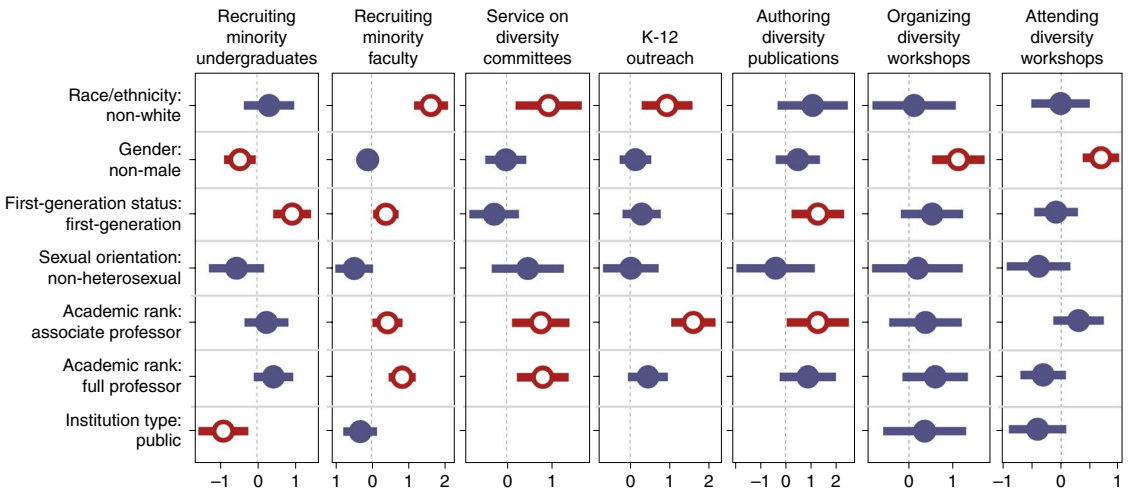

Fig. 1 | Characteristics of faculty that engaged in diversity and inclusion activities. Coefficient estimates and 95% confidence intervals (log scale) are shown for predicted relationships between characteristics of faculty and the frequency in which they engaged in various diversity and inclusion activities per decade ($n = 397$). Red open circles indicate where faculty engaged more (coefficient estimates and confidence intervals > 0) or less (coefficient estimates and confidence intervals < 0) frequently than their colleagues in reference categories (that is, non-Hispanic whites, males, non-first-generation faculty, heterosexuals, assistant professors and faculty associated with private institutions). Blue closed circles indicate insignificant relationships (confidence intervals overlap 0).

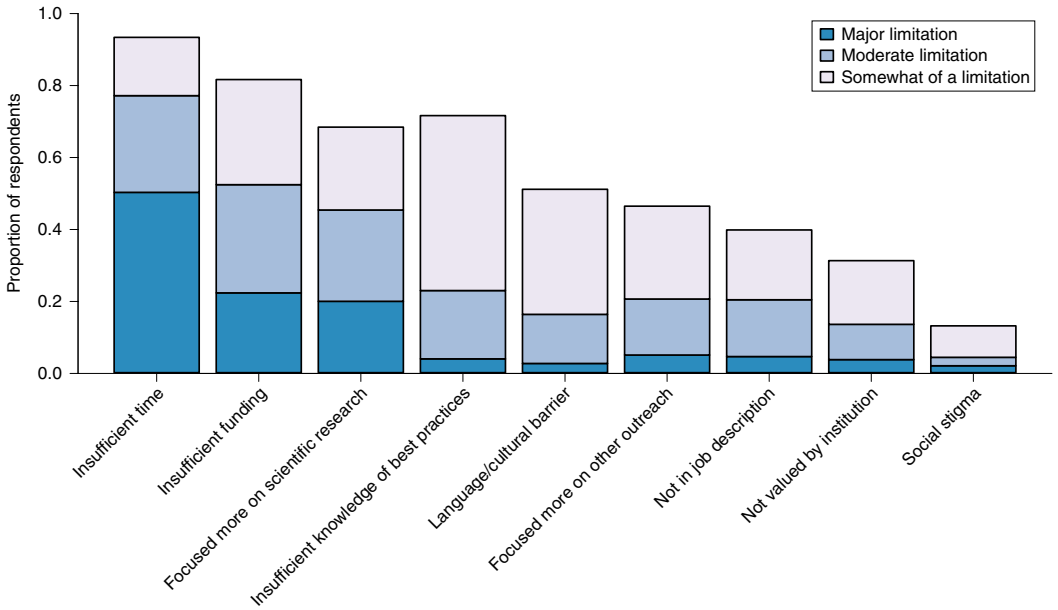

Fig. 2 | Factors limiting faculty participation in activities related to diversity and inclusion. Vertical bars illustrate the proportion of respondents ($n = 469$) that listed each factor as a barrier to engaging in diversity and inclusion activities. Respondents indicated whether they viewed each factor as a major limitation, a moderate limitation, somewhat of a limitation or not a limitation. Those who reported these factors as barriers (that is, major, moderate or somewhat of a limitation) to their engagement in diversity and inclusion activities are displayed as proportions on the stacked bar chart. The remaining proportion of respondents indicated that these factors were not a limitation for their engagement in diversity and inclusion activities.

were motivated by the perception that engagement in diversity and inclusion would enhance success with grants or tenure decisions. The most important factors limiting faculty engagement were insufficient time and funding, rather than training or knowledge (Fig. 2). Consistent with these findings, respondents ranked increased time and funding as the primary pathways for overcoming barriers to engagement (Supplementary Table 4).

Our survey findings indicate that traditionally marginalized groups are bearing the primary responsibility for creating a more diverse and inclusive culture within ecology and evolutionary biology programmes in the United States. Non-white, non-male and first-generation faculty disproportionally reported engaging in and contributing to diversity and inclusion. Our results complement other studies that find underrepresented faculty are more likely to incorporate diversity-related content into course materials[24–26] and contribute more to service than their peers[27]. We expect that faculty that engage in diversity and inclusion would have been more likely to respond to our survey, a potential source of non-response bias. However,

this makes more striking our findings that underrepresented groups were more likely to engage, as these results could be conservative. We suggest that, to achieve a diverse and inclusive discipline, these responsibilities must be shared by all faculty, not just by those who are underrepresented in the field[28].

Most respondents strongly agreed that diversity enhances the quality and relevance of their science, is critical to cultivating the next generation of diverse leaders and promotes scientific literacy (Supplementary Fig. 2). Faculty also widely reported that diversity and inclusion was valued by their institutions. However, they did not think that engagement in diversity initiatives would enhance their ability to obtain tenure (Supplementary Fig. 1), and tenured faculty were indeed more likely to engage than assistant professors (Fig. 1). These findings could reflect a form of cognitive dissonance, in that >90% of our respondents recognized the value of diversity (Supplementary Fig. 2) and reported time and funding as major barriers (Fig. 2). However, few appeared to acknowledge that finite time and resources could be reallocated if diversity and inclusion were more explicitly valued in faculty evaluations for promotion, especially for tenure decisions. We suggest that institutions invest resources to catalyse faculty engagement (for example, recruitment and mentoring of diverse students, inclusive pedagogy and community outreach) and place greater value on these activities in ways that are measurable and do not simply add to current expectations, yet promote shared responsibility for a more diverse and inclusive discipline.

Methods

Faculty survey. We identified our survey population using the National Research Council's list of 94 ecology and evolutionary biology doctoral programmes in the United States[29]. We excluded the Graduate Degree Program in Ecology at Colorado State University, as we conducted two rounds of pre-testing with faculty and graduate students in this programme to improve survey clarity. We compiled faculty email addresses from each programme's website. We included faculty at the assistant, associate and full professor rank. We excluded deans, lecturers, instructors, research scientists, cooperative unit scientists/faculty, extension faculty and emeritus faculty.

We used the tailored design method to develop our survey[30]. We administered the survey online through SurveyMonkey from 21 March to 24 April 2018 (Supplementary Methods). To access the survey, respondents were required to consent to participate in our study and were assured that their responses would remain completely anonymous. We sent an initial invitation to 2,361 valid email addresses, followed by three reminders sent approximately one week apart to respondents who had not completed the survey. We discontinued reminders once returns contributed less than 10% to our total response rate. We received complete responses from 469 individuals, for a response rate of 19.9%. Although this rate is relatively low[31], it is consistent with other online surveys that used email to contact respondents[32,33]. Colorado State University's Institutional Review Board approved all survey and administration procedures before implementation (Protocol No. 270-18H).

Statistical analysis. Due to low numbers of responses for non-white participants, we collapsed data on race and ethnicity into either non-Hispanic white or non-white. Gender data were also collapsed into male and non-male, and sexual identity data were collapsed into heterosexual or non-heterosexual. We removed respondents who preferred not to answer the questions pertinent to each analysis. Additionally, all respondents who selected 'prefer not to answer' or 'prefer to self-describe' in response to questions about their ethnicity, gender or sexual identity were not included in our analyses, since there were too few responses in these categories for inclusion in our models. For two respondents who identified as Hispanic white, we categorized their responses as non-white. We were not able to include veteran status (fewer than ten respondents) as a predictor variable in our models.

We utilized generalized linear mixed effects models (GLMMs) with a negative binomial distribution using the *MASS* package in R v.3.4.2 (ref. [34]) to evaluate relationships between the frequency of faculty engagement in various diversity and inclusion activities and several a priori predictors of interest (Supplementary Table 5). To place all frequencies on the same time scale, we converted weekly, monthly and yearly frequencies to a 'per decade' basis, and set all 'never' responses to a zero value. Our response variable was the number of times faculty engaged in a particular activity per decade, which was modelled as a function of one or more of the following covariates: race/ethnicity (non-Hispanic white or non-white); first-generation status (first-generation or non-first-generation); gender (male or non-male); sexual orientation (heterosexual or non-heterosexual); whether they were born outside the United States (yes or no); institution type (public or private); and academic rank (assistant, associate or full professor). We assessed model goodness-of-fit using the *r.squaredGLMM* function in package *MuMIn*, which calculates R^2 for GLMMs using the method in ref. [35]. We did not interpret the results from models that explained less than 5% variation in the frequency of faculty engagement in diversity-focused activities (Supplementary Table 2). These included models that described graduate student recruitment, involvement in student clubs, teaching of diverse perspectives and mentoring of minority undergraduate or graduate students.

Due to requests to be removed from the initial survey list, we did not follow up with non-respondents. We gauged potential non-response bias by comparing the first and last 20% of respondents[36] across eight demographic and 42 response variables (Supplementary Table 6). Only academic rank and first-generation status were significantly different ($P < 0.05$), suggesting that early respondents were more likely to be tenured professors and/or first-generation college graduates than the overall sample population. Furthermore, we found no significant difference in the proportion of assistant, associate and full professors between our respondents and the entire surveyed population ($\chi^2 = 3.328$, $df = 2$, $P = 0.5045$).

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

The authors declare that the data supporting the findings of this study are available within the paper and its Supplementary Information files.

Code availability

The code that supports the GLMM findings presented here is available within the paper and its Supplementary Information files.

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Author contributions

M.F.J., T.M.L., S.P.B., K.W., D.E.W. and L.P. conceived the study, designed the survey and wrote the manuscript. M.F.J., T.M.L., S.P.B. and K.W. analysed the data. All authors read and approved the final version of the manuscript.

Competing interests

The authors declare no competing interests.

Additional information

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Software and code

Policy information about availability of computer code

Data collection	We used SurveyMonkey to design and implement our survey instrument. Surveys were distributed through email and were accessible online throughout the duration of the study period.
Data analysis	We used R version 3.4.2 for all analyses. The code that supports the GLMM findings is available within the paper and its supplementary information files.

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Behavioural & social sciences study design

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Study description	We designed our study as a quantitative cross-sectional survey.
Research sample	The target population of our study was faculty affiliated with ecology and evolutionary biology graduate programs in the United States. To identify target programs, we used the National Research Council's list of 94 ecology and evolutionary biology doctoral programs in the United States. We excluded the Graduate Degree Program in Ecology at Colorado State University, as we asked faculty in this program to pilot the survey instrument. We included faculty at the assistant, associate, and full professor rank. We also included department heads if they were professors with rank. We excluded deans, lecturers, instructors, research scientists, cooperative unit scientists/faculty, extension faculty, and emeritus faculty.
Sampling strategy	To identify target programs, we used the National Research Council's list of 94 ecology and evolutionary biology doctoral programs in the United States. To generate the survey population, we compiled individual email addresses from each program's website. We sent an initial invitation to participate to 2,361 valid email addresses. We received complete responses from 469 individuals for a response rate of 19.9%.
Data collection	We used the guidelines of the tailored design method to inform the development of the survey and conducted two rounds of pretesting with colleagues at Colorado State University to ensure that questions were clear to respondents. We administered the final online survey through SurveyMonkey from March 21 to April 24, 2018. To access the survey, respondents were required to consent to participate in our study and were assured that their responses would remain completely anonymous. Following the initial invitation, three separate email reminders were sent approximately one week apart to respondents who had partially completed or had yet to begin the survey. No identifying information was collected in our survey.
Timing	We administered the final online survey through SurveyMonkey from March 21 to April 24, 2018.
Data exclusions	We received survey responses from 536 participants. We removed 14 respondents that did not answer any of the survey questions and 53 respondents that did not complete the full survey from the dataset, reducing our overall sample size to 469.
Non-participation	Four participants declined participation. Additionally, 14 respondents consented to taking the survey, but did not answer any of the questions. Lastly, 53 respondents did not complete the full survey. Participants did not provide reasons for declining participation or dropping out of the survey.
Randomization	Participants were not allocated into experimental groups.

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Methods

n/a	Involved in the study
☒	☐ ChIP-seq
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Policy information about studies involving human research participants

Population characteristics	Of the 469 survey respondents, 88% identified as white/Caucasian, 5% as Hispanic/Latino, 4% as Asian/Pacific Islander, 1% as American Indian/Native American and <1% as Black/African American. Just over half (52%) of respondents identified as male, 46% as female, and less than one percent as gender variant/gender non-conforming. The majority of respondents identified as heterosexual (87%). Nearly 1/4 of surveyed faculty (22%) identified as the first generation in their families to attend college, while only 18% of our respondents were born outside the United States. Most respondents were full professors at their institution (50%), while fewer were associate professors (27%) or assistant professors (23%). The majority of our respondents were affiliated with public institutions (89%), while the remaining 11% were affiliated with private institutions.
Recruitment	To identify target programs, we used the National Research Council's list of 94 ecology and evolutionary biology doctoral programs in the United States. To generate the survey population, we compiled individual email addresses from each program's

website. Participation in the online survey was voluntary. We expect that faculty that engage in diversity and inclusion were more likely to respond to our survey, a potential non-response bias that we were unable to evaluate. However, this makes our findings that some groups were more likely to engage than others even more striking, as these results are likely to be conservative. To gauge other potential sources of non-response bias, we compared the first and last 20% of respondents across eight demographic and 42 response variables. Only academic rank and first-generation status were significant ($p < 0.05$), suggesting that early respondents were more likely to be associate or full professors and/or first-generation college graduates than the overall sample population. However, we also compared academic rank between our full sample of respondents and the surveyed population, and found no significant difference in the proportion of assistant, associate, and full professors between the two groups.

Ethics oversight	Colorado State University's Institutional Review Board approved all survey and administration procedures prior to implementation (Protocol #270-18H).

Note that full information on the approval of the study protocol must also be provided in the manuscript.