Towards a new stable state: Equitably assessing trainee writing productivity post-COVID-19

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Contributions

F.E.R., K.A.P., Y.A., M.K.B., A.C.F., and M.C.D. designed the research and distributed the survey. F.E.R. conducted the analyses and K.A.P contributed. F.E.R., K.A.P., Y.A., M.K.B., A.C.F., and M.C.D. interpreted results. F.E.R., K.A.P., Y.A., M.K.B., and A.C.F. wrote the original manuscript. All authors contributed to the editing and the final draft. Middle authors are in alphabetical order.

SHORT BIOGRAPHICAL NARRATIVE

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ABSTRACT

The current academic 'ecosystem' prioritizes publications and has remained in this stable state despite increasing calls for change. Although writing is a strong determinant of academic success, certain groups may experience publishing barriers that may be amplified by disruptive events like the COVID-19 pandemic. Here we surveyed 342 graduate students and postdoctoral scholars to assess (1) how identity predicted publishing outputs and (2) how the pandemic influenced feelings of writing productivity based on identity. We show that there were differential publication totals across identities. Respondents reported feeling less productive and motivated during the pandemic, despite having more time to write. BIPOC graduate students reported being the most negatively impacted. Since the pandemic disproportionately affected historically excluded groups, we urge the academic 'ecosystem' to transition away from an overemphasis on publication outputs and reach a new, more equitable stable state that evaluates accomplishments more holistically.

Keywords: graduate student, identity, pandemic, postdoctoral scholar, publications

Learning the nuances of academic writing is nonlinear and writing challenges can emerge at any point in one's career. Trainees (*i.e.*, graduate students and postdoctoral scholars, hereafter postdocs) are learning how to write manuscripts. For trainees seeking tenure-track positions, successful applicants are often those who published the most (Rybarczyk et al. 2016, Fox 2020). The number of publications by recently-hired trainees has doubled over time (Brischoux and Angelier 2015) and high publication totals are critical for securing academic employment (Sanchis-Gomar 2014).

Despite broad awareness of the importance of academic publishing, there is evidence that writing output is not equal across identity groups. The range of affiliations that one holds, or identity (**Box 1**) can be associated with differential access to writing support and output. Prior to the pandemic, research showed that historically excluded (e.g., Black, Indigenous, People of Color [BIPOC] (**Box 1**), women) graduate students in STEM fields were less likely to publish than white male graduate students (Mendoza-Denton et al. 2017). Many graduate students—especially historically excluded groups (HEGs, **Box 1**) and those whose first language is not English—experience anxiety while writing (Gardner et al. 2018). Although these studies record experiential challenges, they do not quantitatively explore how identity may influence trainee publication outputs.

The importance of increasing diversity within academia is widely recognized (Schell et al. 2020). Yet, faculty hiring is hierarchical and unequal; women are often hired by less prestigious universities than male peers from the same doctoral institutions (Clauset et al. 2015). Women of color, whose experiences intersect race and gender (Ko et al. 2013), are underrepresented in higher levels of academia (National Science Foundation and National Center for Science and Engineering Statistics 2019). Furthermore, some trainees from HEGs may

prioritize improving JEDI ([Justice, Equity, Diversity, and Inclusion], **Box 1**) initiatives within academia. Post-graduation, many women of color reported a strong desire to engage in activism, increase diversity, and improve conditions for other BIPOC women in STEM (Ko et al. 2013). BIPOC women faculty have reported that engaging in activism—rather than focusing solely on research—led to forfeiting their full professor rank but felt advocating for HEGs was more important (Ko et al. 2013).

Increasing diversity in academia necessitates fair assessment of scholars. Academic communities must understand how life experiences affect trainee publishing output, including how identity may intersect with major life upheavals and, further, productivity. The COVID-19 pandemic (hereafter the pandemic) introduced new challenges to the writing process that impacted certain groups more than others (Myers et al. 2020). The productivity disruptions during the pandemic may mirror more singular events that individuals experience such as grief, illness, or unpredictable childcare. Although recent publications highlight how the pandemic affected faculty (Cardel et al. 2020, Myers et al. 2020), there is little understanding of how it impacted trainee writing productivity. We conducted a survey to contextualize how the pandemic and identity may interact to disproportionately affect historically excluded trainees.

The pandemic not only provides an opportunity to examine how major life disruptions differentially affect trainees, but also represents a substantial disturbance to the academic 'ecosystem' (**Fig. 1**). We use the stable state ecology framework (Beisner et al. 2003) to argue that academia is at a tipping point where we can either settle back into the existing state (**Fig. 1B**) or use the disturbance and insights of the pandemic to move toward a more equitable stable state of valuing scientific productivity (**Fig. 1D**).

METHODS

Survey Design and Distribution

During March – April 2021, we used an anonymous Qualtrics survey to ask academic trainees (*i.e.*, graduate students and postdoctoral scholars, hereafter postdocs) currently working at American and Canadian Universities within environmental biology fields to self-identify their demographic information, publication records leading up to the COVID-19 pandemic, career goals, and the effects of the COVID-19 pandemic on their feelings towards writing habits and productivity (full survey available in **Supplementary Information**). We chose to limit the sample frame to minimize differences due to STEM sub-field publishing practices (Mendoza-Denton et al. 2017).

We were approved for IRB exemption under 45CFR46.104 (2)(ii) and did not track any personal identifying information or geographic location (e.g., IP address) to allow for honest and open answers. To encourage responses, we offered respondents the option of entering a gift card drawing not linked to survey responses. Survey completion was voluntary, and we advertised it via social media (Twitter, Reddit, Facebook, Instagram), targeted emails to colleagues, and posted the survey twice on the ECOLOG-L listserv hosted by the Ecological Society of America. To increase the geographic diversity of the sample frame, we emailed 98 different department chairs or graduate coordinators from at least one major public R1 university in each U.S. state and Puerto Rico, U.S. Ivy League institutions, and five R1 Canadian Universities and asked them to distribute our survey among trainees. We did not require respondents to answer all questions, therefore some respondents skipped questions or left fields blank. We eliminated these blank or skipped responses and categorized them as "NA", but as a result, the sample size differs between questions. We denote sample size either in text or in figure captions to account for this.

Data Analysis

We fit Bayesian multiple linear regressions in R version 4.0.2 (R Core Team 2020) using 'rstanarm' (Goodrich et al. 2020) to estimate how training years and identity affect total publications using a Gaussian distribution, and whether identity impacted the probability of a respondent indicating the pandemic affected their writing using a binomial distribution and logit link function. We then used 'bayesplot' (Gabry and Mahr 2020) for visualization. For each model, we used weakly informative normal prior distributions with a mean of zero and standard deviation of 2.5 for predictions, and then allowed rstanarm to automatically scale and center predictors and adjust the scales of priors during the run. We ran four chains for 10,000 iterations and discarded the first half as a warm-up to obtain 20,000 simulations for analysis. We confirmed convergence using Gelman−Rubin statistic ($R_{hat} < 1.01$) and by examining trace plots. None of the models had influential outliers as assessed by leave-one-out cross-validation ("loo") in the 'rstan' package (Stan Development Team 2020).

We used years as a graduate student and as a postdoctoral scholar as continuous variables. Identity factors were coded as whether the respondent was part of the group (yes = 1) or not (no = 0). Identity factors included whether someone was the first in their family to obtain a college degree (first generation); gender identity; whether a trainee identified as BIPOC; whether the trainee had a chronic health condition or disability; and whether the trainee's first language was English or not. Unfortunately, we had too small of a sample size of individuals identifying as non-binary/other (e.g., non-binary, third gender, etc.) to get accurate model results (n = 8/311 respondents), so we eliminated all but those who identify as male or female from the analysis on publication totals. Recognizing that these individual survey respondents have shared insights

from their experiences, we express deep gratitude for their voluntary contributions. Although these data were too minimal to statistically test how being gender non-binary affected publication outcomes, we encourage readers to view a summary of these responses (**Supplementary Table S5)**.

RESULTS

Sample frame

We had 342 survey respondents—290 of whom finished the entire survey—from 149 subfields of environmental biology (**Supplementary Fig. S1**). The most common subfield descriptions included "ecology" (n = 158), "biology" (n = 44), "evolutionary" (n = 34), and "plant" (n = 29). Our sample frame included graduate students from early to advanced stages (0-15 years, avg = 4.7 years, SD = 2.7, n = 231/311), and postdocs who had a similar range of experiences from early to advanced stages (0-9 years, avg = 1.9, SD = 1.9, n = 80/311). The majority of graduate students (73%, n = 140/193) and postdoc respondents (61%, n = 46/76) self-identified as female (**Box 1**), while 34% and 37% (n = 43/197 and n = 28/76; graduate students and postdocs, respectively) self-identified as male, and a small number self-identified as non-binary, third gender, or other (4%, n = 6/193; and 3%, n = 2/76). Most respondents (92%) were previously or are currently at a university in the U.S. or Canada, therefore our results mainly reflect trainee experiences in English-speaking North America.

Overall, 20% (n = 54/311) of respondents self-identified as BIPOC, comprising 24% of graduate students (n = 46/193) and 10% of postdocs (n = 7/74). First-generation college graduates (hereafter first-gen) made up 24% of respondents, with a slightly higher percentage of postdocs (32%; n = 19/59) than graduate students (24%; n = 46/194). Additionally, 18% of

164 respondents reported having a disability or chronic health condition (**Box 1**), with 20% of
165 graduate students (n = 39/193) and 13% of postdocs (n = 10/77). Finally, 18% (n = 36/199) and
166 30% (n = 18/60) of graduate students and postdocs, respectively, reported that English was their
167 second language (ESL, **Box 1**).
168
169 ***Publishing, training, and identity***
170 A substantial number (40%) of trainees had published prior to starting graduate school (n =
171 123/310; comprising the time period before and during the COVID-19 pandemic. Postdocs had
172 more first- (avg = 5.1 versus 1.7) and co-authored publications (avg = 5.6 versus 2.5) on average
173 than graduate students and the variability in both metrics was higher among postdocs
174 (**Supplementary Fig. S2**). The strongest effect on publication total prior to the pandemic was the
175 number of years spent as a trainee (**Fig. 2, Supplementary Tables 1&2**). Each additional year in
176 training resulted in an additional half of a publication for graduate students (β_{hat} = 0.52, 100% of
177 posterior samples [hereafter probability] > 0; **Fig. 2A**) and slightly less for postdocs (β_{hat} = 0.33,
178 82% probability > 0; **Fig. 2B**). Years spent as a postdoc had the strongest effect in the models,
179 with each additional postdoc year resulting in two more publications (β_{hat} = 2.10, 100%
180 probability > 0; **Fig. 2B**).
181 Our models found contrasting effects of identity on publication totals between graduate
182 students and postdocs (**Fig. 2**, **Supplementary Tables 1&2**). First-gen identity was associated
183 with a slight increase in publication totals for graduate students (β_{hat} = 0.44, 79% probability >
184 0), but had little effect on postdocs (β_{hat} = -0.75, 67% probability < 0). Female identity was a
185 neutral factor for graduate students (β_{hat} = -0.03, 52% probability < 0), but reduced postdoc
186 publication total by 1.4 (β_{hat} = -1.39, 81% probability < 0). BIPOC graduate students had slightly

fewer publications than non-BIPOC peers (β_{hat} = -0.28, 69% probability < 0), but BIPOC postdocs published more papers than non-BIPOC peers (β_{hat} = 1.40, 70% probability > 0). Graduate students with chronic conditions had approximately one fewer paper (β_{hat} = -0.80, 91% probability < 0), but postdocs with chronic conditions had more papers (β_{hat} = 1.58, 77% probability > 0). Graduate students with ESL had slightly fewer papers than non-ESL peers (β_{hat} = -0.35, 76% probability < 0). Having ESL had little effect on publishing productivity of postdocs (β_{hat} = -0.76, 65% probability < 0), although ESL trainees were the only identity to provide qualitative descriptions of their difficult experiences in an open response (**Table 1**).

Differential impact of the COVID-19 pandemic

The majority of respondents (70%, n = 197/279) reported that the pandemic impacted their writing habits (**Fig. 3A**). Despite most trainees (52%, n = 101/195) reporting having more or much more time for writing during the pandemic (**Fig. 3B**), a combined 75% of respondents (n = 147/196) reported that they felt less or much less productive during the pandemic (**Fig. 3C**). Similarly, 76% (n = 148/196) of respondents reported feeling less or much less motivated to write during the pandemic (**Fig. 3D**).

The differential writing outputs across trainees prior to the pandemic is now exacerbated by the ongoing pandemic as shown by qualitative data regarding respondents' feelings towards writing productivity. Specifically, the majority of female-identifying respondents (74%, n = 131/176) reported that the pandemic impacted their writing habits, compared to 61% of those who identify as male (n = 46/75) and 63% (n = 5/8) of non-binary trainees. Strikingly, 85% of BIPOC trainees reported that their writing habits were impacted by the pandemic compared to 67% (n = 142/212) of white peers. Our models that accounted for identity and years in graduate

school supported these results and suggested with a high degree of certainty (**Supplementary Table S3**) that first-gen, female-identifying, or BIPOC graduate students were more likely to have the pandemic negatively impact their writing habits (**Fig 4A**). First-gen graduate students had a 72% probability and female-identifying graduate students a 61% probability of answering that their writing was negatively affected. BIPOC graduate students had the highest (89%) probability of reporting the pandemic negatively affected their writing. Number of years spent in graduate school was unrelated to the impact of the pandemic on writing (1 year = 51% versus 5 years in graduate school = 54% probability). Interestingly, graduate students with ESL were strongly unlikely to report that the pandemic affected writing habits (100% posterior < 0), with only a 17% probability (**Fig. 4A**, **Supplementary Table S3**).

Among postdocs, those who have spent longer in postdoctoral training and who identify as female were the most likely to report that the pandemic affected their writing, whereas postdocs with chronic conditions and ESL were statistically unlikely to report an effect on writing habits (**Fig. 4B**, **Supplementary Table S4**). Each additional year of postdoc training increased the probability of the pandemic negatively affecting writing habits by 6% (96% posteriors > 0; e.g., 1 year postdoc prob = 57% versus 4th year prob = 75%). Female-identifying postdocs had a 66% probability of being affected by the pandemic (89% posteriors > 0). Postdocs identifying as first-gen and BIPOC reported little to no effect of the pandemic on writing (**Fig. 4B, Supplementary Table S4**). Postdocs with ESL had only a 20% probability (98% posteriors < 0) of saying the pandemic affected their writing, and postdocs with chronic conditions a 22% probability (95% posteriors < 0).

DISCUSSION

We show the pandemic substantially and unequally affected writing habits of trainees and argue for a shift to a new stable state with how academia values success and productivity. The negative impacts of the pandemic were disproportionately experienced by HEGs — 85% of BIPOC and 74% of female-identifying trainees reported that their writing habits were impacted. Our results suggest that the pandemic may worsen diversity in academia because its current structures and insufficient support may push historically excluded trainees to leave the academic pipeline. To reach a new, more resilient (Walker et al. 2004) and equitable stable state in the academic 'ecosystem' after the pandemic disturbance (**Fig. 1D**), we must acknowledge that basing hiring practices mainly on trainee publication output disadvantages HEGs and ignores other strengths that academic candidates might offer.

Diversity, equity, and inclusion in scientific writing

Our results strongly demonstrate that female-identifying trainees and those with chronic conditions have lower publication output at some point during training compared to their peers (**Fig. 2**). Interestingly, graduate students and postdocs often had contrasting results with respect to how identity affected publication output. Graduate students had similar publication records across genders, but female-identifying postdocs had 1.4 fewer publications than their male-identifying counterparts. Postdocs are more likely to have children than graduate students, and this could disproportionately affect the child-carrying and primary caregiving partner, although further research is needed to explore this. However, even for women without children, gender schemas guide perceptions and make it harder to succeed in academia (Valian 2004). Notably, the 'leaky pipeline' in academia, where women leave during the transition from graduate student

255 to postdoc (National Science Foundation and National Center for Science and Engineering
256 Statistics 2019) and from postdoc to faculty (Martinez et al. 2007), continues to exist.
257 First-gen graduate students had more publications than their non-first-gen peers but there
258 was no difference at the postdoctoral level (**Fig. 2**). Others have found first-gen biology doctoral
259 students have similar experiences and outcomes as non-first-gen peers, matching our results
260 (Roksa et al. 2018), but our weak trend at the postdoctoral level shows that we need more data to
261 understand how first-gen postdocs might respond to pressures of graduate school versus
262 postdoctoral positions. BIPOC trainees and trainees with chronic conditions tended to have fewer
263 publications as graduate students but more as postdocs (**Fig. 2**). People from HEGs finishing
264 STEM PhDs are half as likely to have submitted a paper in the previous year (Mendoza-Denton
265 et al. 2017) and in-depth surveys suggest high writing anxiety among BIPOC biomedical
266 graduate students (Gardner et al. 2018), similar to our results. Graduate students experience
267 major institutional sources of stress during their degrees including role strain (e.g., being a
268 teacher but also a student), mentor relationships, isolation, and funding concerns (Grady et al.
269 2014); how these graduate school stressors may build upon the strain of being part of a HEG
270 needs to be explored and addressed.
271 Trainees with ESL had slightly fewer publications than trainees with English as a first
272 language. Although these trends were weak, many respondents explicitly mentioned the
273 struggles of English as the default language of science in the open response section (**Table 1**).
274 Research shows that trainees with ESL face enormous obstacles to scientific publishing (Powell
275 2012), but writing intervention programs have helped this group gain confidence and skills in
276 scientific writing (Gardner et al. 2018). Universities should invest in extra resources for trainees
277 with ESL, including discipline-specific writing courses (Allison et al. 1998, Lax 2002).

Our results, alongside previous work (Mendoza-Denton et al. 2017), demonstrate that certain groups of trainees had lower publication outputs than their peers leading up to the COVID-19 pandemic. We need to improve the academic 'ecosystem', currently structured to differentially impact identity groups under baseline conditions and highly disruptive events like the pandemic. Not doing so limits the ability of talented scientists to publish their work in peer-reviewed journals, which hurts not only their career prospects, but also their universities.

COVID-19 pandemic

Graduate students and postdocs have navigated the impacts of the pandemic at a critical time in their careers when publishing matters most for their future career success. While recent studies have examined the effect of the pandemic on early-career faculty (Cardel et al. 2020, Myers et al. 2020, Herman et al. 2021), our study is the first to our knowledge that quantitatively examines the impact of the pandemic on trainees (but see Suart et al. (2020) for a qualitative overview). The differential writing outputs across trainees may be exacerbated by the ongoing pandemic. The majority of trainees reported that the pandemic has affected their writing habits, with most feeling less productive and motivated to write (**Fig. 3**). This finding is not surprising; mental health was already a concern for trainees (Evans et al. 2018), and the pandemic will likely worsen anxiety and depression (Woolston 2020a, Abbott 2021). Furthermore, 70% of respondents preferred working in non-home environments that were unavailable during lockdown. Many trainees were likely adjusting to working from home while living in smaller, shared spaces with roommates or family. Trainees who are parents had the additional challenge of caring for their children; women have been disproportionately affected by increased childcare

or other family caretaking responsibilities stemming from the pandemic (Cardel et al. 2020, Myers et al. 2020, Pinho-Gomes et al. 2020).

There was no effect of years spent in graduate school, but each additional year of postdoctoral work strongly increased the reported effect of pandemic on writing habits (**Fig. 4**). Most postdoctoral positions in environmental biology fields are for 2-3 years at most, so losing 1.5 years of access to networking, lab work, and field sites was devastating, especially when paired with grim job prospects (Kelsky 2020, Levine and Rathmell 2020) and the importance of publishing during postdoctoral work (Fox 2020). Despite calls for more support and contract extensions (Ahmed et al. 2020, Park 2020), many universities did not accommodate postdocs. Postdocs are deeply concerned that the pandemic has worsened their overall career prospects (Park 2020, Woolston 2020b).

Interaction of the COVID-19 pandemic with identity

The pandemic has not affected all trainees equally. We found evidence that female-identifying trainees were disproportionately affected. The experience of non-binary and other gender trainees was similar (**Supplementary Table S5**), but more data are needed to more fully characterize their experience throughout the pandemic. Other studies have also reported gender inequalities in research productivity during the pandemic, including women having less time for research (Myers et al. 2020) and being underrepresented in COVID-19-related research and authorship (Andersen et al. 2020, Pinho-Gomes et al. 2020, Bell and Fong 2021). Actions such as creating niche funding opportunities to support gender minorities and developing flexible working schedules for those with childcare responsibilities have been proposed as strategies for supporting these early-career scientists (Cardel et al. 2020). Additionally, creating institutional

323 resources for writing (*e.g.*, courses, workshops, support groups) could help mitigate the effects of
324 unexpected disturbances.

325 Disparities in the pandemic's impact on writing were most pronounced for BIPOC
326 respondents. A striking 85% of BIPOC trainees reported that the pandemic negatively affected
327 their writing habits, and overwhelmingly felt unproductive and unmotivated to write. The timing
328 of the pandemic also coincided with the collective trauma felt by Black Americans in response to
329 police brutality and the murders of Breonna Taylor and George Floyd, among others.
330 Furthermore, violence directed at Asian Americans has been on the rise in the U.S. during the
331 pandemic (Nuyen 2021). We recognize that this violence transcends workspaces and can
332 manifest in field work settings as well (Demery and Pipkin 2021). Although our data do not
333 differentiate between the public health and social justice crises, the compounding issues of the
334 pandemic, racism, and the rise of racially-charged violence likely contributed to the decreased
335 writing motivation felt by BIPOC trainees. It is critical for BIPOC trainees to take care of their
336 mental health (Tseng et al. 2020), and for academic communities to support and retain BIPOC
337 trainees by dismantling institutional white supremacy and creating inclusive environments where
338 BIPOC scholarly excellence is celebrated (Maas et al. 2020, Schell et al. 2020, Cronin et al.
339 2021). Future research should aim to disentangle the role of longstanding inequities in academia
340 and the effects of recent events (e.g., the pandemic and the social justice movement of 2020) on
341 work output.

342 First-gen graduate students were also more likely to report a disruption to writing during
343 the pandemic, which may be due to the mental toll of having more family and friends with low
344 socioeconomic status who struggled more throughout the pandemic (Ojha 2020). Surprisingly,
345 trainees with ESL and those with chronic conditions were statistically less likely to report the

pandemic affected their writing habits (**Fig. 4**). More research is needed to understand why these trainees reported less interruption to writing habits.

The intersection of identities, such as race and gender, is important (Charleston et al. 2014) and undoubtedly would add new insight and a fine-tuned understanding of how different identities were affected by the pandemic. Though we did not analyze the intersections of race, gender, first-gen, ESL, and chronic conditions/disability to retain statistical power, we encourage future studies to quantitatively assess intersectionality of different identities and include more nuance in their assessments.

A new stable state

We show that the pandemic disproportionately affected historically excluded environmental biology trainees. Female-identifying, BIPOC, and first-gen trainees were much more likely to indicate that the pandemic negatively impacted their writing. These writing interruptions may linger on the CVs of those who were trainees during the pandemic, manifesting as disparities in publication counts compared to more productive colleagues and competitors. To recover post-pandemic from the disturbance to our academic 'ecosystem', we must provide enhanced writing support and reconsider how to evaluate productivity and establish values for future academic hiring. The current evaluation metrics are not equitable because they do not (1) account for the different input into individual publications or (2) give equal weight to the non-publishing aspects of academia (e.g., teaching, mentoring, JEDI). Research projects that are theory-, lab-, or field-based require different inputs from inception to publication. Search committees should consider these project inputs when evaluating candidates beyond total publication counts and journal impact factors. Further, while peer-reviewed publications

maintain the quality and knowledge-base of science, the non-publishing aspects of academia—essential for improving the academic 'ecosystem'—should be given more weight in the evaluation process. Non-white, non-male, and first-gen faculty are more likely to participate in JEDI activities (Jimenez et al. 2019); if trainees engaging in and prioritizing institutional service and JEDI initiatives have similar identities, these individuals may have less time to dedicate to writing. The fact that participation in these important initiatives is not equal amongst identities further highlights the lack of equity in the current evaluation process. Ultimately, we need to improve the system that perpetuates inequity prior to future major disturbances.

To conclude, committees should evaluate faculty candidates holistically not only for scientific contributions (e.g., publications stemming from research grants), but also seek well-rounded individuals who will serve as good advisors and community members. Although there have been small disturbances to the academic system calling for change (Nocco et al. 2021) or support for HEGs (Maas et al. 2020, Tseng et al. 2020) (**Fig. 1A**) we urge the ivory tower to use the pandemic disturbance to finally move beyond its overemphasis on publication totals as an almost singular metric of scientific success (Brischoux and Angelier 2015) (**Fig. 1B**). We propose moving to a new stable state (Beisner et al. 2003) of comprehensively assessing trainee contributions to the 'ecosystem' by including service, teaching, mentorship, and JEDI initiatives (**Fig. 1D**). In transitioning to a new stable state, the academic 'ecosystem' could become more inclusive, vibrant (Hansen et al. 2018), and resilient to future disturbances and perturbations.

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FIGURES AND TABLES

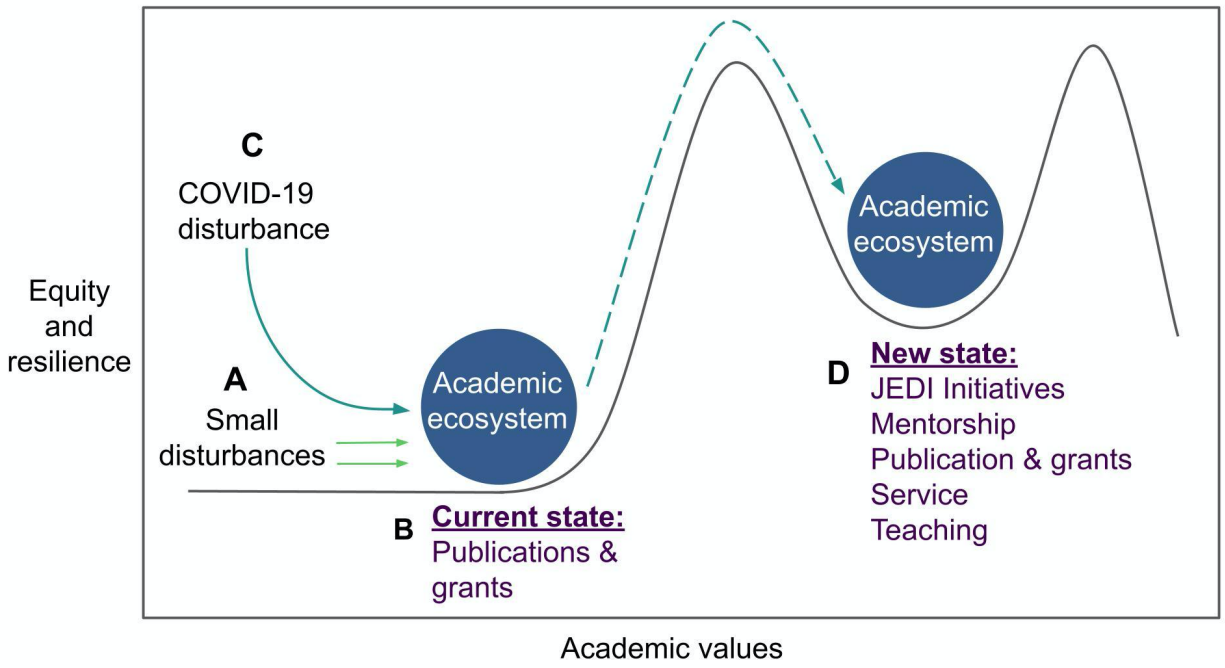
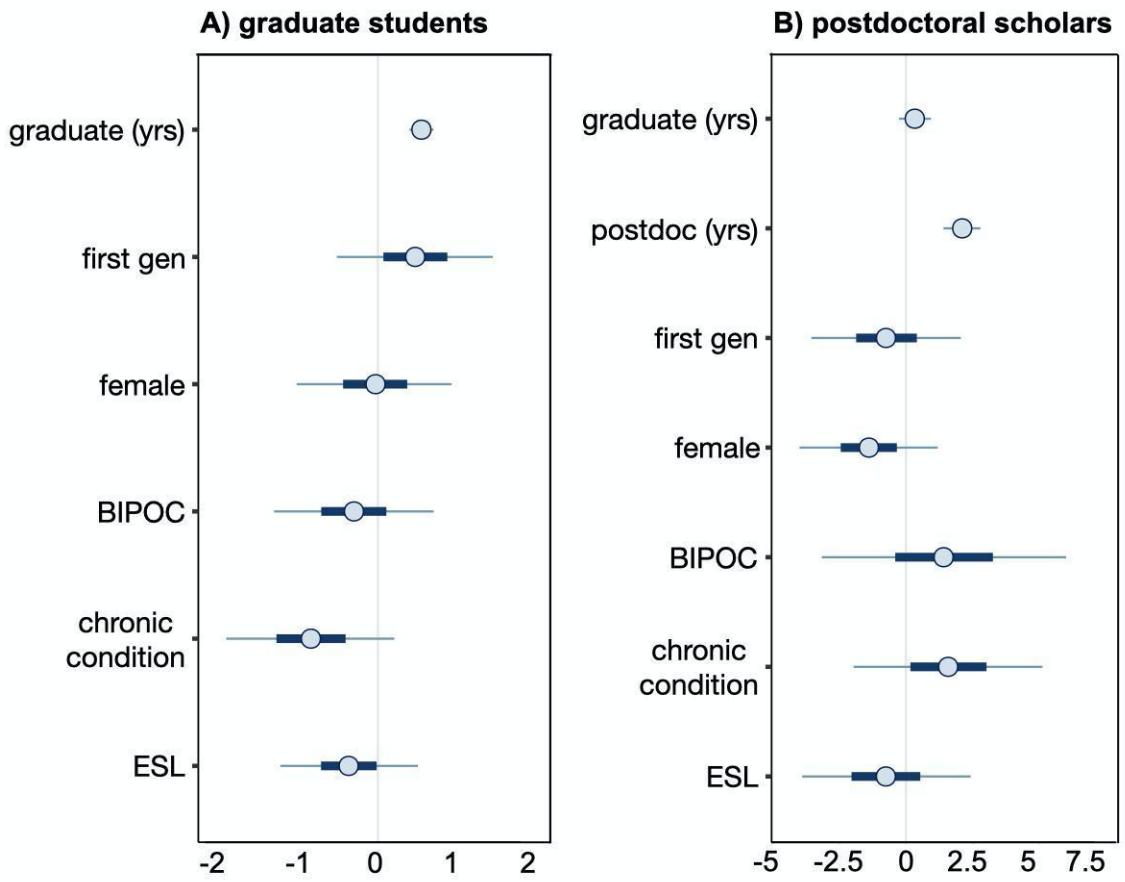


Fig. 1. Using an ecological framework, the COVID-19 pandemic is a major disturbance that can push the academic ecosystem to a new, more equitable state. A) The academic ecosystem has experienced small disturbances calling for change to the system, such as the need to diversify. B) Within the current state of the academic ecosystem, the main metric of success is publications and grants. C) The disturbance of the COVID-19 pandemic can shift the academic ecosystem to a new, more equitable stable state. D) This new stable state is characterized by equal valuation of the publishing and non-publishing aspects of academia, and individuals are valued holistically.



406

407 **Fig. 2.** Multiple regression models suggest identity of graduate students and postdoctoral
408 scholars influences publication totals. The effect of years in training and identity on total
409 publications for A) graduate students (n = 229) and B) postdoctoral scholars (n = 79) leading up
410 to the COVID-19 pandemic. Points are the posterior medians, thick lines are 50% credible
411 intervals (CRIs), and thin lines are 95% CRIs. Graduate and postdoc yrs indicate the number of
412 years in training. First gen = first in family to graduate from college. Female = female-
413 identifying respondents. BIPOC = Black, Indigenous, and/or a person of color. Chronic
414 condition = chronic health condition or disability. ESL = respondents with English as a second
415 language.

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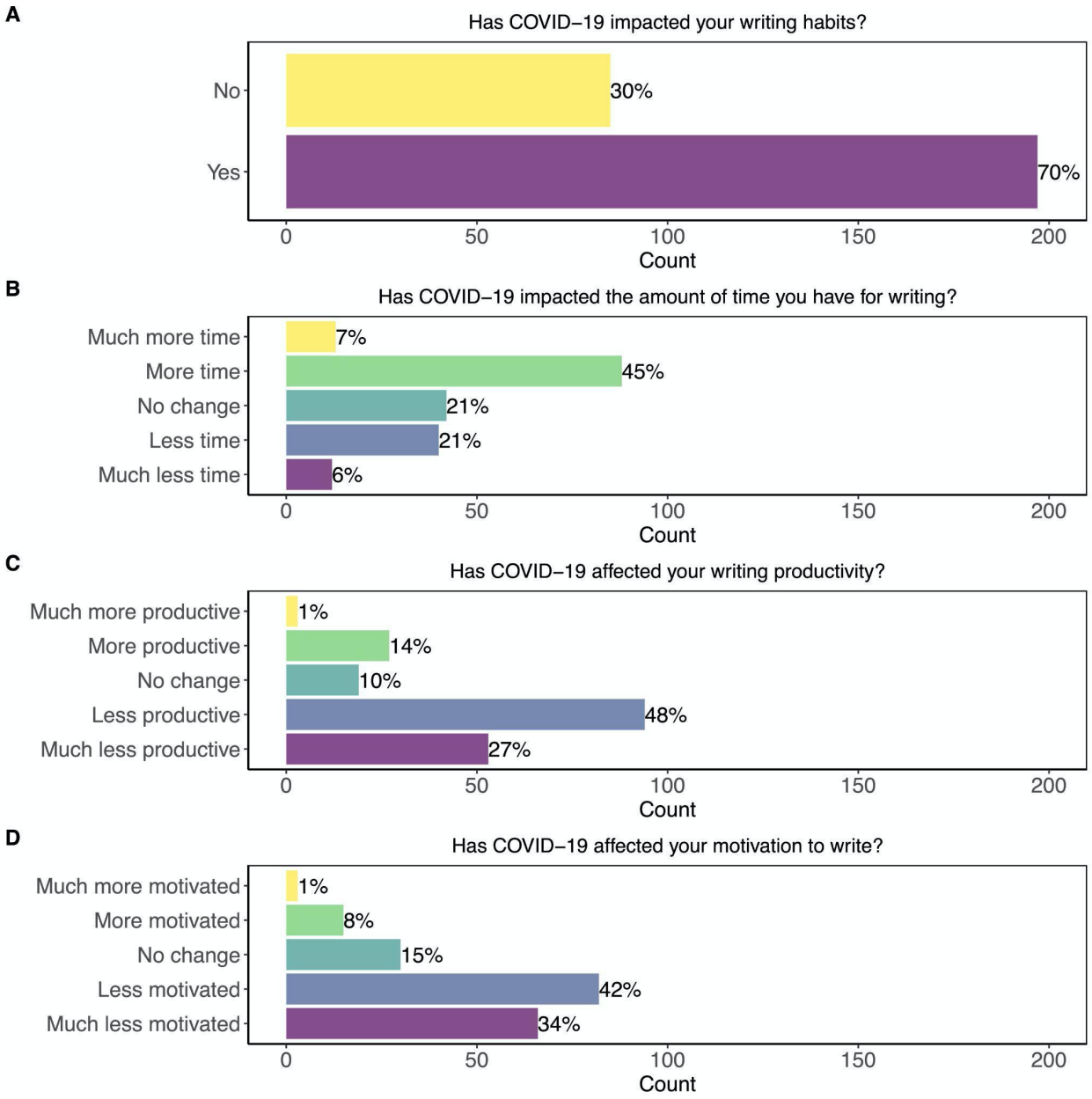

Fig. 3. The impact of the COVID-19 pandemic on trainee writing habits and feelings of productivity and motivation. A) The majority of respondents said that the pandemic has affected their overall writing habits. B) While many respondents reported having more or much more time for writing, C) most respondents reported that they felt less or much less productive during the pandemic. D) Similarly, the majority of respondents reported feeling less or much less motivated.

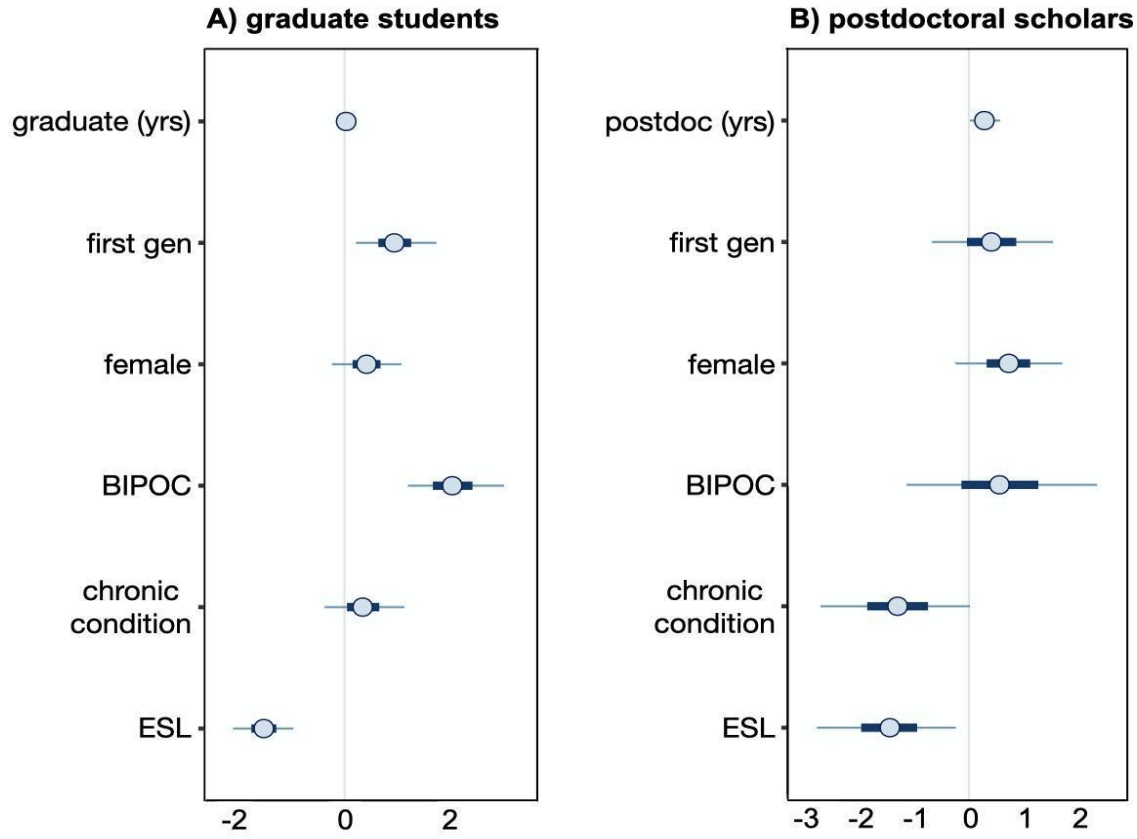

Fig. 4. Binomial multiple regression models suggest identity of graduate students and postdoctoral scholars influenced yes/no responses among A) graduate students (n = 229) and B) postdoctoral scholars (n = 79) to the question "*Has COVID-19 impacted your writing habits?*" All estimates are in logit scale for ease of comparison. More positive values indicate a higher probability of answering "yes." Points are the posterior sample medians, thick lines are 50% credible intervals (CRIs), and thin lines are 95% CRIs. Graduate and postdoc yrs indicate the number of years in training. First gen = first in family to graduate from college. Female = female-identifying. BIPOC = Black, Indigenous, and/or a person of color. Chronic condition = chronic health condition or disability. ESL = English is the second language of respondents.

Table 1. In the optional open question "*Is there anything else you would like to add about your writing experiences?*" trainees with ESL were the only ones who responded about how their identity affected publishing. While the model indicated that having ESL was not detrimental to publication output, these stated experiences of trainees with ESL highlighted the challenges.

Career stage	**Gender identity**	**Comment**
graduate student	male	*"As a non-native speaker, the hardest part is to find the right words to properly communicate. But it is rewarding to see a final product, even if it's just a paragraph."*
postdoc	male	*"English writing obligation is unfair"*
graduate student	female	*"[It is] especially hard being a non-native English speaker. Many mental roadblocks and perfectionism make it nearly impossible to be motivated to write. Also, I don't get positive feedback often enough, which makes me feel like I'm not writing well enough and not capable of science."*
postdoc	male	*"Many times I don't know how to express what's in my mind in English. [I spend] a lot of time to find appropriate words for what I want to say."*
graduate student	female	*"The most difficult part for me has been training my brain to think in English. My first language is Spanish and I learned English …[at] 23 years old, so always I need a native speaker to check my docs. The [lack of] language diversity in science obligates people to think, write, and speak in English, which makes it difficult …"*
postdoc	none given	*"A lot of people have issues due to [having ESL] and it should be taken more into account in Academia."*
graduate student	female	"*I have found writing challenging, especially because English is my second language…"*

Box 1. Terminology

We have strived to be as inclusive as possible throughout the process of creating and distributing our survey, as well as through our choice of language, while trying to maintain statistical power. Prior to finalizing our survey, we solicited feedback on the best language to use for certain questions that pertained to identity. When discussing **identity** as a whole, we used the American Psychological Association (VandenBos 2007) definition as "an individual's sense of self defined by (a) a set of physical, psychological, and interpersonal characteristics that is not wholly shared with any other person and (b) a range of affiliations (e.g., ethnicity) and social roles." Here we describe the identity terminology that we chose to use in our survey and writing. To remain consistent, we use these terms throughout our writing.

We asked survey respondents to self-identify their gender as "**female**," "**male**," "**non-binary/third gender**," or they could select "**prefer to self-identify**." Thus, when referring to female and male genders we are not implying the biological sex of individuals, but rather employing the terms as adjectives of their gender identity.

We use **Black, Indigenous, and People of Color (BIPOC)** to refer to groups that have faced and are facing racism. Where possible, we try to center all these groups rather than using the term non-white, which still centers white people. We recognize that BIPOC individuals come from diverse and unique backgrounds, and therefore do not all have the same experience. In the survey, individuals specified whether they identified as BIPOC or not.

The term individuals with a **chronic condition** describes individuals with a chronic health condition or disability. We understand that many people within the disability community prefer person-first language (*i.e.*, person with a disability), while others prefer identity-first language (*i.e.*, disabled person). We use the term individuals with a chronic condition to be inclusive of all types of disability and chronic health conditions.

Trainees with **English as a second language (ESL)** were those who did not have English as their first language. We use the term ESL to encompass trainees who speak English as a foreign language (EFL) and English as an additional language (EAL). We did not differentiate international trainees (*i.e.*, those studying or working in countries that are not their native country) and in-country trainees with ESL, but we recognize that many respondents with ESL may also be international trainees.

Historically excluded groups (HEGs) refers to any group of people who have been excluded from full rights and privileges based on historical systems of oppression. This can include, but is not limited to, female-identifying individuals, non-binary or third gender individuals, BIPOC individuals, and individuals with chronic health conditions. We chose not to use the term 'underrepresented minority' as the term 'historically excluded' better encompasses the power dynamics and systems of oppression that governed which groups were excluded.

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ETHICS DECLARATIONS

The authors declare no conflicts of interest.

DATA STATEMENT

We have another manuscript in prep from this work, and then will publish the complete dataset as a data paper on Dryad for anyone to use. If BioScience needs us to publish the data we used in this manuscript sooner on Dryad, we will gladly do that.