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Contingent faculty in ecology and STEM: an uneven landscape of challenges for higher education

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Abstract. The number of contingent or non-tenure-track faculty at colleges and universities in the United States has been growing over the past several decades; they now constitute nearly 70% of the non-student academic workforce. A significant fraction of contingent faculty teaches in the fields of science, technology, engineering, and mathematics (STEM). As an initiative of the Ecological Society of America (ESA), contingent faculty in ecology were surveyed and the results were compared with a survey of STEM faculty conducted by the Coalition for the Academic Workforce (CAW). Most respondents to the ESA survey were employed in research or research and teaching activities at doctorate-granting institutions, whereas in the CAW sample, most were engaged in teaching at associate's and master's degree-granting institutions. The ESA sample was almost evenly divided between women and men; women outnumbered men in the younger age classes, whereas men outnumbered women in the older age classes. The respondents to the CAW survey were older than the ESA respondents, with more men in computer sciences, engineering, and physical sciences, more women in the biological and health sciences, and a balanced gender ratio in mathematics. The ESA survey asked respondents to rank possible activities that ESA could undertake to support contingent faculty. The highest ranked activities included reduced fees for membership, page charges, and meeting registrations, followed closely by small grants for travel and research. The lowest ranked was the formation of an ESA section for contingent faculty. The causes and implications of contingency are analyzed in light of other recent surveys. Academic institutions and professional societies such as the ESA can reduce the loss of qualified individuals from the scientific community by recognizing and legitimizing contingency as an academic career stage and by offering professional development to support the careers of contingent faculty.

Key words: academic career stages; adjunct faculty; Coalition for the Academic Workforce; contingent faculty; diversity; Ecological Society of America; gender; higher education; non-tenure-track faculty; part-time faculty; professional societies; women.

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Introduction

Contingent or non-tenure-track faculty filled 69.5% of instructional positions in the United States in 2015, up from 57.6% in 1995 (GAO 2017). According to the American Association of University Professors (AAUP 2003), "[t]he term 'contingent faculty' includes both part- and full-

time faculty who are appointed off the tenure track." Part-time faculty constituted 40.9% of the full academic labor force in 2014, with full-time non-tenure-track faculty making up another 16.7% (Barnshaw 2016). Contingent faculty, dubbed "the fast-food workers of the academic world" (Hoff 2014), were profiled in *The Guardian* and *The New York Times* as struggling to survive in academia (Swarns 2014), some taking desperate measures to make a living teaching part-time (Gee 2017). Contingent faculty also constitute a significant fraction of the growing temporary scientific workforce that supports contemporary team science, where the half-life of ecology and astronomy cohorts has dropped from 35 to 5 yr from 1960 to 2010 (Milojevic et al. 2018).

Part-time instructors, paid by the number of classes that they teach, are perhaps the most commonly recognized class of contingent faculty. Some contingent faculty also teach full-time, generally with one- or two-year contracts and no guarantee of permanent employment. In the natural sciences, contingent faculty not only teach, but often do research. Since nearly all researcher positions are filled on a contingent basis with grant funds, few research faculty have the expectation of permanent employment, as funding can end without warning. One well-recognized group of researchers are individuals in temporary postdoctoral appointments performing research and acquiring training under the supervision of mentors. Beyond this initial training phase, however, individuals may occupy contingent positions that stretch to become a career stage as research or adjunct faculty. Frequently, adjuncts are individuals whose main employment is outside the academy and who may teach one or two classes in which they have particular expertise. But adjunct faculty may also be non-tenure-track faculty who derive most of their income from teaching and/or research, which leads to some ambiguity. Another class of non-tenure-track faculty also performs some administrative duties, including committee and supervisory responsibilities. Given the diversity of positions and roles, contingent faculty appears to be the most inclusive and widely accepted term, as in the report by the United States General Accounting Office (GAO 2017), and so is adopted here.

The increasing employment of faculty on a contingent basis in higher education presents important challenges, not only for the faculty, but also for the educational enterprise itself (Childress 2019). Contingent faculty may be less likely to use innovative, learning-centered teaching methods compared to tenured faculty (Umbach 2007, Baldwin and Wawrzynski 2011), which may negatively impact student retention (Jaeger and Eagan 2011). Anecdotal evidence, however, suggests that contingent faculty may be more likely to devote time to enhance student learning and to engage in innovative pedagogical activities. Meanwhile, contingent faculty often are dissatisfied with the mismatch between their career aspirations and their professional reality, which typically includes lower pay (Monks 2007), lack of access to institutional resources (Hurtado et al. 2012), and lack of opportunities for advancement, particularly for younger faculty (Feldman and Turnley 2004), compared with their tenure-track counterparts. More research is thus needed on the systemic impacts of contingent faculty employment on higher education and on this faculty class.

In the natural sciences, the issue of contingent positions has received less attention than in the social sciences or humanities, possibly because of higher demand for tenure-track faculty leading to fewer individuals in contingent positions. In addition, recent PhDs often take postdoctoral positions that may lead to other research positions, spending fairly long periods of time in contingent research positions before being offered tenured appointments. Given this diversity of preconditions and lack of recognition of contingency as a career stage, relatively little information is available on contingent faculty in science, technology, engineering, and mathematics (STEM) disciplines.

As an initiative endorsed by the Ecological Society of America (ESA) Governing Board, we conducted a survey of contingent faculty in ecology to determine their numbers, demographic characteristics, and professional aspirations and constraints. We also inquired about the challenges faced by contingent faculty and asked how the ESA could help advance their professional development. To our knowledge, this is the first study that focuses on contingent faculty in ecology. In addition, we compared our survey

results with responses for faculty in all STEM disciplines from a survey carried out by the Coalition for the Academic Workforce in 2010 (CAW 2012).

Through our survey, we also explored whether the contingent employment conditions of women in ecology differed significantly from that of men. In the United States (and Europe), women earn about 50% of the science and engineering doctorates, yet they comprise only 20% of full professors (Shen 2013, Vernos 2013) and 25% of tenured academics (McCook 2013). Women in the humanities, social sciences, and STEM were more likely to hold contingent positions than men from 1983 to 1995, although many acquired tenure-track positions after having children (Wolfinger et al. 2009). In 1995, two-thirds of female faculty members across all disciplines were contingent, compared with only half of all male faculty, while in 2001, women were still overrepresented among contingent faculty and underrepresented among tenured/tenure-track faculty in STEM disciplines, but without clear cause (Ivey et al. 2005). Of ecology PhDs earned between 2000 and 2011 (52.3% female, 47.7% male) and employed in academia, 50.2% of female PhDs were contingent (cf. 27.6% of all PhDs) in 2013, comprising a disproportionate 63.8% of non-tenure-track faculty from this cohort (Hampton and Labou 2017). The GAO (2017) reported that women occupied 53.1% of contingent instructional positions in 2015, although they pointed out that this resulted partially from the greater proportions of women at 2-yr (54.3%) and for-profit institutions (55.9%; GAO 2017). At 4-yr institutions, the proportion of women contingent faculty was 52%.

Women in academia face gender discrimination (Reuben et al. 2014), unequal pay, funding disparities, and the challenges of reconciling work and family, which makes them more likely to exit from academic careers (Husu 2005, Shen 2013) or to occupy contingent faculty positions. The underrepresentation of women in tenured/tenure-track faculty positions has been attributed to differential application rates, exiting the tenure-track for contingent positions because of interpersonal and family reasons, departmental climate, and delays in receiving tenure (Kaminski and Geisler 2012, Shen 2013). Parenthood often leads new parents, particularly new mothers in STEM, to switch to part-time employment in STEM and full-time employment outside of STEM, or to leave the academic workforce entirely (Cech and Blair-Loy 2019). Notably, in a survival analysis of faculty in science and engineering by gender, men and women were retained and promoted at the same rate in science, technology, and engineering, but not mathematics (Kaminski and Geisler 2012). Here, we examine the recruitment and retention conditions of contingent faculty by gender, as temporary contingency may be an overlooked bottleneck that preferentially hinders women's access and progress to tenured careers in science.

Methods

In November 2012, in coordination with the ESA Committee on Diversity and Education, we surveyed ecologists who had contingent positions at some point in their careers to determine their numbers and how the ESA might help currently contingent faculty attain their professional goals. The survey consisted of 33 questions administered through SurveyMonkey from 5 November 2012 through 9 December 2012. The survey was advertised via email to ESA members and ECOLOG, a list serve for the community of ecologists, including non-ESA members. We received 559 responses, of which 536 were complete. Twenty-three respondents answered only the first two or three questions, designed to filter out non-contingent respondents. Seventy-eight respondents appeared to have postdoctoral appointments, being engaged primarily in research during the first five years after receiving their PhDs. First and second postdoctoral appointments are considered academic training and so were treated separately in subsequent analyses except where noted. In our survey, 282 respondents identified themselves as currently contingent for 10 yr or less, which represents about 27% (an upper bound) of the 1049 identified contingent faculty in ecology who received their PhDs between 2000 and 2011 in the United States (Hampton and Labou 2017). The Institutional Review Board of Wilkes University approved the survey.

The ESA survey (Appendix S1) consisted of 13 questions about the respondent's type of employment and institution and six questions about

demographic characteristics. Each respondent was asked about their current or previous status as contingent faculty, how many years since they were employed as contingent faculty, how many years they were employed as contingent faculty, their title, and the fraction of their salary that came from their contingent position. They were also asked whether their primary duties were teaching, research, teaching and research, teaching and administrative, research and administrative, or teaching and research plus administrative duties. Based upon the responses to this last question, the respondents remaining in the sample, after removing the postdoctoral fellows, were divided into two groups: research and teaching. The research group included those who listed research, teaching and research, research plus administrative, or teaching and research plus administrative duties, while the teaching group included those who listed teaching and teaching plus administrative duties. Respondents were also asked about the sources of funding for their positions, as well as the types of institutions where they were employed, according to the Basic Carnegie classification and funding type (public or private). Demographic questions dealt with the highest degree earned, age group, gender, ethnicity, and ESA membership. These were followed by 15 questions about possible activities that ESA could undertake to promote the professional development of contingent faculty, such as workshops, mentoring, reduced fees, awards, recruitment services, and support for travel and research.

The CAW (2012) survey of contingent faculty ran from 27 September 2010 to 30 November 2010. Of the 28,974 respondents, 3762 responses were deemed inadequate for analysis by the CAW group because the respondents did not sufficiently identify their positions, which left 25,212. We downloaded the results of the CAW survey (http://www.academicworkforce.org/CAW_portrait_2012.pdf) to see the distribution of contingent faculty in the STEM disciplines and to compare the results with those of the ESA survey. For the purposes of our study, STEM faculty were those who listed their primary specializations in the following STEM disciplines: biological sciences, computer sciences, engineering, mathematics, other health sciences (excluding nursing), and physical sciences. There were 2915 respondents (11.6%) who met this criterion, ranging from 669 in the biological sciences to 219 in engineering; 44 respondents who listed their specialization as simply "Sciences" were excluded from our analysis. Sample sizes for each STEM discipline in the CAW survey are similar to those in the ESA survey.

The age categories used in the CAW survey were <25, 26–35, 36–45, 46–55, 56–65, 66–75, and >75, whereas those used in the ESA survey were 20–30, 31–40, 41–50, 51–65, and >65. To make the age categories compatible between the two studies, we randomly reassigned respondents in the CAW survey with ages 26–35 to either 20–30 or 31–40. Similarly, we randomly reassigned respondents with ages 36–45 to either 31–40 or 41–50 and those with ages 46–55 to either 41–50 or 51–65. All other CAW respondents were reassigned to the ESA age categories that corresponded to their ages.

Data on the number of doctorate recipients in ecology from 1958 through 2016 were provided by the National Science Foundation Survey of Earned Doctorates (https://www.nsf.gov/statistics/srvydoctorates/). Data on the ethnic composition of the scientific workforce came from Science and Engineering Indicators 2018 (National Science Board 2018) and from a survey conducted in 2013 by the National Survey of College Graduates (NSCG; https://ncsesdata.nsf.gov/us-workforce/2013).

Database construction and analyses of contingency tables were carried out using JMP 11.0 Statistical Software (SAS Institute 2013). We used Wordle (www.wordle.net) to generate a word map, in which the size of a word reflects its relative frequency in the comments.

Results and Discussion

Overview of employment conditions

According to our ESA survey results, contingent faculty in ecology did not have the same profile as STEM faculty in the CAW survey (CAW 2012). The ecologists were younger overall and more likely to occupy research positions, with only 35.5% engaged in teaching and teaching plus administration (Table 1), compared to 71.8% of STEM faculty in the CAW survey. Furthermore, 57.0% of respondents to the ESA survey were employed full-time, compared to 50.4%

Table 1. Distribution (%) of ESA and CAW STEM respondents by age class, gender, and primary activity.

Survey	Gender	Age class					Row total (%)
		20–30 (%)	31–40 (%)	41–50 (%)	51–65 (%)	>65 (%)	
ESA							
Overall	Female	2.2	23.7	11.2	8.9	1.1	47.1
Overall	Male	2.5	19.4	11.2	15.4	4.5	52.9
Total (n = 448)		4.7	43.1	22.3	24.3	5.6	100.0
Research group	Female	1.7	22.2	11.4	7.3	1.0	43.6
Research group	Male	2.1	21.4	12.1	16.3	4.5	56.4
Total (n = 289)		3.8	43.6	23.5	23.5	5.5	100.0
Teaching group	Female	3.1	26.4	10.7	12.0	1.3	53.5
Teaching group	Male	3.1	15.7	9.4	13.8	4.4	46.5
Total (n = 159)		6.3	42.1	20.3	25.8	5.7	100.0
Postdoctoral	Female	12.8	43.6	1.3	0.0	0.0	57.7
Fellows	Male	3.8	33.3	3.9	1.3	0.0	42.3
Total (n = 78)		16.7	76.9	5.1	1.3	0.0	100.0
CAW							
Overall	Female	4.8	11.1	13.8	18.8	1.9	50.4
Overall	Male	3.7	8.2	11.1	19.2	7.6	49.6
Total (n = 2370)		8.4	19.2	24.9	38.0	9.5	100.0
Biological sciences	Female	6.1	15.9	17.9	20.8	1.8	62.5
Biological sciences	Male	2.2	6.9	10.5	13.9	4.0	37.5
Total (n = 552)		8.2	22.7	28.4	34.8	5.8	100.0
Computer sciences	Female	1.4	4.6	11.2	21.2	2.4	40.8
Computer sciences	Male	3.6	7.8	13.8	26.8	7.2	59.2
Total (n = 250)		5.0	12.4	25.0	48.0	9.6	100.0
Engineering	Female	2.0	6.3	8.3	8.0	0.0	24.6
Engineering	Male	2.6	9.4	18.6	32.3	12.6	75.4
Total (n = 175)		4.6	15.7	26.9	40.3	12.6	100.0
Mathematics	Female	5.3	11.1	11.7	18.0	3.0	49.2
Mathematics	Male	5.2	8.2	8.5	19.4	9.5	50.8
Total (n = 571)		10.5	19.4	20.2	37.5	12.4	100.0
Other health sciences	Female	3.9	12.2	21.9	30.5	1.7	70.2
Other health sciences	Male	3.1	5.3	7.2	12.2	2.1	29.8
Total (n = 292)		7.0	17.5	29.1	42.6	3.8	100.0
Physical sciences	Female	5.8	10.1	10.4	13.4	1.5	41.1
Physical sciences	Male	4.2	10.9	12.6	20.4	10.8	58.9
Total (n = 530)		9.9	21.0	23.0	33.8	12.3	100.0

Notes: CAW, Coalition for the Academic Workforce; STEM, science, technology, engineering, and mathematics. Respondents who declined to answer were not included in the analyses; hence, the totals do not always match the total number of questionnaires returned.

of CAW STEM faculty and 42.2% of all faculty in the CAW survey (CAW 2012).

Demographic characteristics

The ESA sample was almost evenly divided between women and men, with almost half in the 31–40 age group (Table 1). This is consistent with the approximate 1:1 ratio of female to male doctorates in ecology in 2012 when this survey was conducted, a ratio that has increased steadily since the early 1970s (Fig. 1). In our survey, women outnumbered men in the 20–30 and 31–40 age classes, transitioned to roughly equal for ages 41–50, and were outnumbered by men in the 51–65 and over 65 age classes. If the majority of doctorates are earned between the ages of 20 and 30, given the trend in Fig. 1, this suggests that women were overrepresented in our contingent sample, particularly in the teaching group. Notably, men outnumbered women in the research group, while this was reversed in the teaching group. A total of 89% of survey respondents were ESA members.

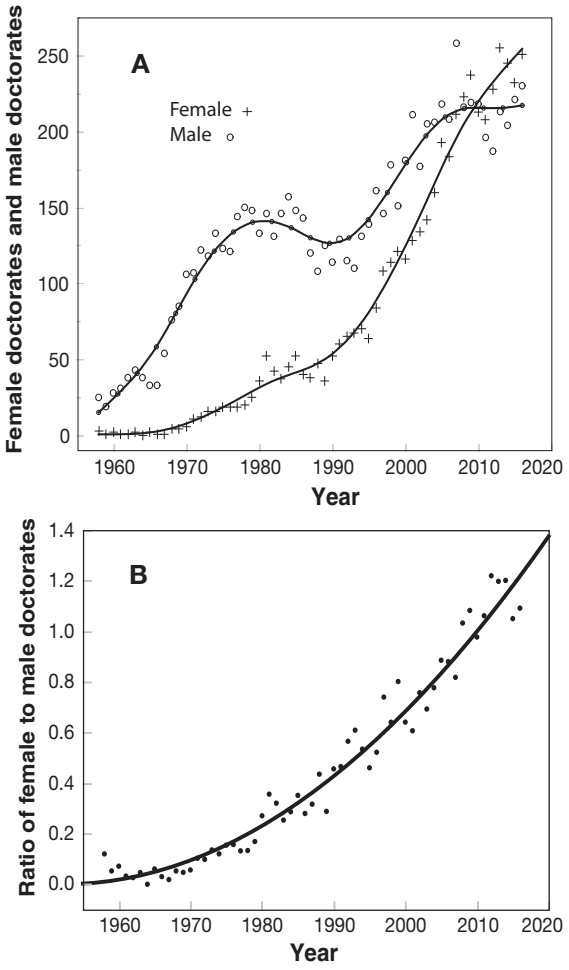

Fig. 1. (A) Number of female (F, plus sign) and male (M, circle) doctoral recipients in ecology from 1958 to 2016 (NSF Survey of Earned Doctorates). Lines are fit by cubic spline. (B) Ratio of female to male doctoral recipients (F/M) in ecology from 1958 to 2016. Square root (F/M) = −33.78 + 0.0173 yr. R^2 = 0.95.

The respondents to the CAW survey were older, with 51–65 being the largest age group for all STEM specializations (Table 1). The ratio of women to men reflected historical gender imbalances, with more men in computer sciences, engineering, and physical sciences, and more women in the biological and health sciences. Only in mathematics was the gender ratio approximately equal.

By looking at the gender distribution in the younger age classes (Table 1), we could forecast future distributions. For example, the proportion of female contingent ecologists was larger in the younger age classes for the teaching group and about equal for the research group, reflecting the increased participation of women in ecology in recent years. Women comprised the majority of postdoctoral fellows in the ESA survey (57.7%). From the CAW survey, current trends forecast more women contingent faculty in the biological and other health sciences and more men in computer science and engineering. Mathematics and ecology may be acquiring more female contingent faculty, whereas the physical sciences may be approaching gender balance.

Ethnic composition

Of the 488 respondents to the ESA survey who answered the question about ethnicity, 87.5% claimed European ancestry, 5.1% Mixed, 3.2% Hispanic, 2.5% East Asian, 1.0% South Asian, and less than 0.1% (one individual each) for African, African American, and Pacific Islander groups (Table 2). This resembles the ESA's membership ethnic profile in 2012 when the survey was conducted (https://esajournals.onlinelibrary.wiley.com/doi/epdf/10.1890/2012.councilreport): 66% white, 5% Asian, 4% Hispanic, 1% African American, <1% Native American, and 24% other or left blank. These proportions are markedly different from those reported in Science and Engineering Indicators 2018 (National Science Board 2018) for 137,000 biologists (i.e., ecologists, botanists, and zoologists), where 76.6% of survey respondents self-identified as white, 12.4% as Asian, 5.1% as Hispanic, 4.4% as more than one race, and 2.2% as black (the proportions of Native Americans and Pacific Islanders were not reported for reasons of confidentiality and/or reliability). Data from the NSCG survey in 2013 indicated that in the category of biological/agricultural/other life scientists, the ethnic and racial composition was 70.2% white, 18.5% Asian, 6.6% Hispanic, 3.0% black, 1.6% other race, and 0.2% Native American. Thus, there seems to be a lower proportion of respondents of Asian descent in the pool of contingent faculty in ecology than in the population of biological scientists taken as a whole, which suggests that they were less likely to specialize in ecology or more likely to secure tenured positions. On the other hand, they may have been less inclined to respond to the survey. The ethnic composition of the

postdoctoral fellows was similar to that of contingent faculty, except that there was a higher proportion (9.3%) of respondents of Hispanic ethnicity compared to the proportion in the contingent sample (2.2%).

A similar pattern prevailed for the CAW survey of 2332 contingent faculty (Table 3). Respondents had a similar ethnic composition to those of the ESA survey, with 90.2% white, 3.7% Asian or Pacific Islander, 2.2% Hispanic, 1.9% black, 1.4% multiracial, and 0.5% Native American (Table 3). In contrast, the 2013 NSCG had a composition of 66.9% white, 20.5% Asian, 5.6% Hispanic, 5.3% black, 1.6% other race, and 0.1% Native American for a combined sample of life scientists, computer/mathematical scientists, and physical scientists. Again, there seem to be fewer contingent faculty of Asian descent than would be expected based on their representation in the pool of graduates with degrees in scientific fields.

We analyzed the ESA sample for the distribution of ethnicities between full- and part-time contingent employment, separating those currently employed as postdocs. This left 412 respondents to represent the current population of contingent faculty. There was a tendency for more non-Europeans in the ESA survey to be employed part-time (Table 2). This was not the case for the CAW survey, where approximately the same numbers of all groups were employed full-time as part-time (Table 3).

Employment duties

Nearly one third (31.0%) of contingent faculty respondents to the ESA survey were employed to teach only, with the remainder fairly evenly divided among research only (23.3%), teaching and research (24.2%), and teaching and/or research plus some administrative responsibilities (21.5%) (Table 4). The duties of full-time (57.0%) and part-time (43.0%) respondents differed markedly, however; most who had primarily teaching responsibilities were employed part-time, whereas most with primarily research responsibilities (with or without teaching and/or administrative duties) were employed full-time (Table 4). Two-thirds of the postdoctoral fellows were engaged in research, while the rest were divided equally between research plus teaching and research plus administrative duties.

Respondents to the CAW survey were asked to list their primary occupation as teaching, research, non-teaching academic, such as staff or administration, non-academic, and retired (CAW 2012). An overwhelming 71.8% of CAW respondents listed teaching as their primary occupation, with 9.0% in research, 4.4% non-teaching academic, 8.9% non-academic, and 5.9% retired (Table 5). Respondents to the CAW survey were roughly equally divided between full-time (50.4%) and part-time (49.6%) employment (Table 5) but were distributed differentially by specialization (Table 5). More were employed full-time in the biological sciences (54.0%), engineering (57.1%), and other health sciences (60.7%). On the other hand, more were employed part-time in the computer sciences (58.2% part-time) and mathematics (56.9%). In the physical sciences, respondents were approximately equally distributed with 49.6% working full-time (Table 5).

Institution type

Nearly 2/3 (64.5%) of the ESA survey respondents worked at doctorate-granting institutions,

Table 2. Distribution of ESA survey respondents' ethnicity by full-time and part-time contingent employment (n = 412).

	Ethnicity								
Employment	African	African American	East Asian	European	Hispanic	Mixed	Pacific Islander	South Asian	Row total (%)
Full-time	0.0	0.0	1.0	51.0	1.0	2.2	0.0	0.7	55.8
Part-time	0.2	0.2	1.7	36.9	1.2	3.2	0.2	0.5	44.2
Total	0.2	0.2	2.7	87.9	2.2	5.4	0.2	1.2	100.0
Postdoctoral Fellows									
Full-time	0.0	0.0	1.3	85.4	9.3	4.0	0.0	0.0	100.0

Note: Postdoctoral fellows (n = 75) were analyzed separately.

Table 3. Distribution of CAW STEM survey respondents' race or ethnicity by full-time and part-time contingent employment (n = 2332).

Employment	Race or ethnicity						Row total (%)
	Asian or Pacific Islander	Black	Hispanic	Multiracial	Native American	White	
Full-time	2.0	0.7	0.9	0.6	0.2	46.0	50.4
Part-time	1.7	1.2	1.3	1.64	0.6	44.3	49.6
Total	3.7	1.9	2.2	1.4	0.5	90.3	100.0

Note: CAW, Coalition for the Academic Workforce; STEM, science, technology, engineering, and mathematics.

Table 4. Distribution of ESA survey respondents' duties by full-time and part-time contingent employment (n = 451).

Employment	Duties				Row total (%)
	Teaching only (%)	Research only (%)	Teaching and research (%)	Teaching and/or research + administrative duties (%)	
Full-time	8.4	16.2	16.6	15.7	57.0
Part-time	22.6	7.1	7.5	5.7	43.0
Total	31.0	23.3	24.2	21.5	100.0
Postdoctoral Fellows					
Full-time	0.0	66.7	16.7	16.7	100.0

Note: Postdoctoral fellows (n = 78) were analyzed separately.

with most engaged in research activities (Table 6). Not surprisingly, most contingent faculty at non-doctorate-granting institutions were engaged in teaching only (Table 6). Nearly all postdoctoral fellows (94.5%) were at doctorate-granting institutions. In contrast, over half of the CAW survey respondents were at Associate's degree-granting institutions, followed by master's institutions, where they were engaged primarily in teaching (Table 7). Even at doctorate-granting institutions, most CAW respondents were engaged primarily in teaching.

Length of career in contingent status

The ESA survey results were analyzed further to determine career trajectories for contingent faculty: Do they eventually get tenure, get jobs outside of academia, or leave the labor force altogether? As job titles were not available, we compared the distributions of lengths of contingent employment for currently and previously contingent faculty (Table 8). Length of employment was divided into four classes: 0–1 yr; 2–5 yr; 6–10 yr; and 10+ yr. The percentage of respondents in each of the classes beyond 0–1 yr is greater for currently contingent faculty than for those who were previously contingent, which suggests that currently contingent faculty maintain that status for slightly longer than did those in the past. At the same time, the numbers of contingent faculty are likely increasing, as shown by the approximately 4:1 ratio of currently contingent to formerly contingent (Fig. 2, Table 8) and documented by other sources (GAO 2017). However, comparison of trends across currently and previously contingent faculty may have been biased by fewer formerly contingent respondents than is representative, as those who had left the field of ecology may have been less likely to see the survey while those who were no longer contingent may have been less likely to complete it. This analysis of our survey results leads to the tentative conclusion that contingent employment is an increasingly populated and protracted academic career stage.

To assess whether there is any gender bias in the contingent faculty population, we examined the gender distribution of currently and previously contingent faculty respondents. The results in Fig. 2 show that for currently contingent faculty, women and men were roughly equally represented, with slightly more female (50.8%) than male respondents. This suggests an overrepresentation of women in the

Table 5. Distribution of CAW survey respondents' primary occupation by STEM disciplinary specialization and by full-time and part-time contingent employment.

Specialization	Employment	Primary occupation					Row total (%)
		Teaching (%)	Research (%)	Non-teaching academic (%)	Non-academic (%)	Retired (%)	
Overall	Full-time	40.7	6.3	2.6	0.6	0.0	50.1
Overall	Part-time	31.1	2.7	1.9	8.3	5.9	49.9
Total (n = 2473)		71.8	9.0	4.4	8.9	5.9	100.0
Biological sciences	Full-time	42.4	9.0	2.4	0.2	0.0	54.0
Biological sciences	Part-time	32.6	3.6	1.9	4.0	3.8	46.0
Total (n = 576)		75.0	12.7	4.3	4.2	3.8	100.0
Computer sciences	Full-time	36.1	1.5	3.8	0.4	0.0	41.8
Computer sciences	Part-time	29.7	0.4	4.6	17.5	6.1	58.2
Total (n = 263)		65.8	1.9	8.4	17.9	6.1	100.0
Engineering	Full-time	45.6	9.3	2.2	0.0	0.0	57.1
Engineering	Part-time	15.9	6.0	1.1	14.8	4.9	42.9
Total (n = 182)		61.5	15.4	3.3	14.8	4.9	100.0
Mathematics	Full-time	37.4	4.2	1.3	0.2	0.0	43.1
Mathematics	Part-time	39.1	1.3	1.7	5.7	9.2	56.9
Total (n = 601)		76.5	5.5	3.0	5.8	9.2	100.0
Other health sciences	Full-time	42.3	9.5	5.6	3.3	0.0	60.7
Other health sciences	Part-time	21.0	0.7	2.6	13.1	2.0	39.3
Total (n = 305)		63.3	10.2	8.2	16.4	2.0	100.0
Physical sciences	Full-time	42.3	5.1	2.0	0.2	0.0	49.6
Physical sciences	Part-time	32.1	4.4	0.5	6.6	6.8	50.4
Total (n = 546)		74.4	9.5	2.5	6.8	6.8	100.0

Note: CAW, Coalition for the Academic Workforce; STEM, science, technology, engineering, and mathematics.

Table 6. Distribution of ESA survey respondents' duties by type of institution (n = 479).†

Institution type	Duties				Row total (%)
	Teaching only (%)	Research only (%)	Teaching and research (%)	Teaching and/or research plus administrative duties (%)	
Doctorate	11.9	19.6	17.7	15.2	64.5
Master	8.8	1.0	3.8	2.3	15.9
Baccalaureate	6.1	0.4	2.5	2.3	11.3
Associate	5.4	0.2	0.4	0.6	6.7
Special focus	0.6	0.4	0.2	0.4	1.7
Column total	32.8	21.7	24.6	20.9	100.0
Postdoctoral fellows					
Doctorate	0.0	63.0	15.1	16.4	94.5
Baccalaureate	0.0	0.0	2.7	1.4	4.1
Special focus	0.0	1.4	0.0	0.0	1.4
Total	0.0	64.4	17.8	17.8	100.0

Note: Postdoctoral fellows (n = 73) were analyzed separately.

† Individuals who worked at more than one type of institution were counted for each listed institution type; hence, the sample size here is larger than in Tables 1, 2.

contingent pool, as ecology doctorates only reached rough gender parity around 2010. When faculty who have been contingent for more than 10 yr are excluded, the proportion of women rises to 53.3% of the contingent pool, lower than the proportion of 63.8% of PhDs in ecology from 2000 to 2011 reported by Hampton and Labou (2017). Both results,

Table 7. Distribution of CAW survey respondents' duties by type of institution (n = 1257).

Institution type	Duties					
	Teaching (%)	Research (%)	Non-teaching academic (%)	Non-academic (%)	Retired (%)	Row total (%)
Doctorate	10.1	3.3	0.7	2.9	2.2	19.2
Master	14.6	0.2	0.9	4.5	2.2	22.4
Baccalaureate	3.5	0.2	0.4	0.6	0.7	5.3
Associate	34.9	1.8	1.9	7.7	6.1	52.4
Special focus	0.4	0.1	0.0	0.0	0.1	0.6
Column total	63.5	5.6	3.9	15.7	11.3	100.0

Note: CAW, Coalition for the Academic Workforce.

Table 8. Distribution of ESA survey respondents by contingent status and length of employment (n = 445).

Contingent status	n	Length of employment				Row total (%)
		0–1 yr (%)	2–5 yr (%)	6–10 yr (%)	10+ yr (%)	
Complete sample						
Currently contingent	355	15.5 (19.4)	30.5 (38.3)	17.3 (21.7)	16.4 (21.6)	79.8 (100.0)
Previously contingent	90	5.2 (25.6)	9.4 (46.7)	3.4 (16.7)	2.2 (11.1)	20.2 (100.0)
Column total	445	20.7	40.0	20.7	18.6	100.0
Research group						
Currently contingent	236	11.8 (14.4)	30.9 (37.7)	20.5 (25.0)	18.8 (22.9)	81.9 (100.0)
Female		*8.0*	*20.8*	*10.2*	*8.0*	*47.0*
Male		*6.4*	*17.0*	*14.8*	*14.8*	*53.0*
Previously contingent	52	3.1 (17.3)	8.3 (46.2)	4.2 (23.1)	2.4 (13.5)	18.1 (100.0)
Female		*5.8*	*15.4*	*7.7*	*1.9*	*30.8*
Male		*11.5*	*30.7*	*15.4*	*11.5*	*69.2*
Column total	288	14.9	39.2	24.6	21.2	100.0
Teaching group						
Currently contingent	119	22.3 (29.4)	29.9 (39.5)	11.5 (15.1)	12.1 (16.0)	75.8 (100.0)
Female		*18.5*	*23.5*	*6.7*	*9.2*	*58.0*
Male		*10.9*	*16.0*	*8.4*	*6.7*	*42.0*
Previously contingent	38	8.9 (36.8)	11.5 (47.4)	1.9 (7.9)	1.9 (7.9)	24.2 (100.0)
Female		*15.8*	*18.4*	*2.6*	*0.0*	*36.8*
Male		*21.0*	*29.0*	*5.3*	*7.9*	*63.2*
Column total	158	31.2	41.4	13.4	14.0	100.0
Postdoctoral Fellows	72					
Female		*33.3*	*25.0*			*58.3*
Male		*20.8*	*20.8*			*41.7*
Total		54.2	45.8			100.0

Note: Postdoctoral fellows were analyzed separately. The upper percentage in each cell is the percent of the total ESA sample, whereas the lower percentage in parentheses is the percent of the sample by contingent status (currently or previously). Gender proportions are presented in italics.

however, indicate that women with recent PhDs were more likely to be employed in contingent positions than were men. This conclusion applies mainly to contingent teaching positions where 58.8% were women, whereas research positions were divided almost equally between women (47.0%) and men (53.0%). For previously contingent faculty, men were more strongly represented (69.2%), which reflects the higher ratio of male to female ecologists in the past (cf. Fig. 1), but also lower retention of women in the contingent workforce. Although the reasons for lower retention are not clear, one possibility is that men were likely to be hired into tenure-track positions. This assumes that previously contingent respondents were likely now tenured, which seems reasonable if they responded to the survey.

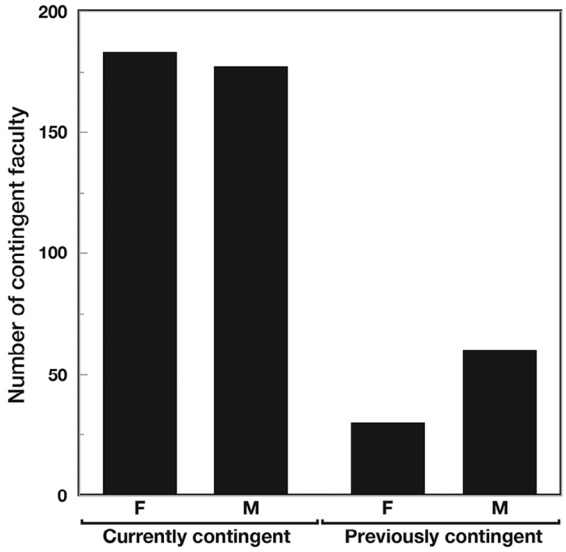

Fig. 2. Distribution of respondents by gender (F, female; M, male) and contingent status. Postdoctoral fellows were excluded from the analysis.

Length of contingent employment was similar for men and women, currently and previously contingent faculty, in both the teaching and research groups (Table 8). Interestingly, the teaching group tended to have shorter terms of employment than the research group. Almost 45.8% of the research group had been employed as contingent for more than five years, whereas only 27.4% of the teaching group were employed for that length of time. Thus, a substantial number of ecologists appear to spend a large portion of their careers in contingent positions doing research, which suggests that it is a career stage experienced by many researchers, as well as teachers. However, contingency has been hitherto largely unrecognized by academic institutions and professional societies. To avoid the social stigma often associated with this employment category, contingent faculty need to be legitimized as a dominant part of the academic workforce and given more institutional support.

Professional development activities

Toward this end, we asked respondents to rate eleven possible activities that the ESA could undertake to promote the professional development of contingent faculty in ecology. These activities are listed in Table 9, along with respondents' mean scores, based on a scale ranging from 1 (most important) to 5 (least important). This analysis included postdoctoral fellows, as they are potential future contingent faculty whose opinions regarding professional development activities should be considered.

Respondents identified reduced fees for membership, page charges, and meeting registrations as the most important proposed activity, followed closely by small grants for travel and research. The ratings of these proposed activities were not significantly different by Tukey's honestly significant difference test. Recruitment services and sponsored workshops for professional development and career guidance were also favored. The least important proposed activity was to form an ESA section for contingent faculty, which is consistent with several written comments which emphasized that contingent faculty should not be placed in a separate group from their tenured or tenure-track colleagues. For all activities, there was no significant difference in preferences among respondents engaged in "Research," "Teaching," "Teaching and Research," and "Administrative duties with teaching and/or research." Respondents, when asked to list their three most important and three least important activities, were consistent in their responses with the mean scores above: Reduced fees, small grants for travel, and small grants for research were listed as most important, while forming an ESA section for contingent faculty and joining the Coalition on the Academic Workforce were least important. These results suggest that contingent faculty feel most restricted in their professional development by lack of funds to develop, present, and publish their research and opportunities to network and to engage with their colleagues.

For six of the eleven proposed activities, there was no difference by gender. Women, however, rated small grants for travel, small grants for research, and networking opportunities as significantly more important than did men (Wilcoxon test, $P < 0.05$). For two other activities, merit-based awards and recruitment services, the differences between women and men were marginally significant ($P < 0.07$), with women attaching slightly more importance to these activities than did men. Women who are contingent faculty might benefit more from recognition by and

Table 9. Respondents' mean score ratings of activities that the ESA could undertake to promote the professional development of contingent faculty in ecology, ranging from (1) most important to (5) least important.

Professional development activity	Mean score
Reduced fees for membership, page charges, and meeting registration	2.15
Small grants for travel for contingent faculty	2.16
Small grants for research for contingent faculty	2.20
Recruitment services, such as listing of available positions or award opportunities	2.32
Sponsoring workshops addressing specific concerns of contingent faculty in professional development and career guidance, such as effective communication, teaching skills, enhancing publications, grant writing, conflict resolution, leadership training, life–work balance, applying for jobs, job interviews, negotiating contracts	2.45
Merit-based awards restricted to a pool of candidates drawn from contingent faculty	2.56
Joining the Coalition on the Academic Workforce (www.academicworkforce.org), which advocates for equitable treatment for contingent faculty	2.59
Networking opportunities for contingent faculty to collaborate with each other and with the membership-at-large	2.59
Formulating a statement on behalf of the ESA concerning employment conditions for contingent faculty, as several societies in the humanities and social sciences have done	2.60
Mentoring for contingent faculty from established ecologists such as guidance and introductions at the annual meeting, leadership retreats, and other networking activities	2.62
Forming a section for contingent faculty	3.02

Note: The responses of postdoctoral fellows were included in this summary.

active support from ESA than would men. They are younger on average and likely to be less established in their careers, and therefore might benefit more from opportunities for professional development. Women also suffer more discrimination than men from not being recognized for their accomplishments (Husu 2005).

The highest ranked activities in support of contingent faculty, namely reduced membership, conference, and publication fees or small travel and research grants, would reduce revenues (or increase expenses) for the ESA. As many professional societies, including the ESA, are facing increased financial pressure, support for such undertakings may be low. Furthermore, some contingent faculty may be reluctant to identify themselves as such to their peers, given the social stigma that often accompanies non-tenured status. On the other hand, the rise of open-access publishing and concomitant publication fees may exacerbate the resource differential between contingent and salaried faculty.

In the mid-rank of desired activities were opportunities to engage in networking. While the greater availability of scientific literature on the Internet and social media may reduce the need for contingent faculty to subscribe to journals and attend meetings to stay current in their fields, face-to-face networking remains critical for relationship-building and career advancement opportunities. Professional societies can proactively sponsor workshops that focus on specific topics or skills identified by their memberships to be of interest. ESA already sponsors the Life Discovery—Doing Science Biology Education Conference (https://www.esa.org/ldc/) at minimal registration cost, supplemented with travel awards, as well as regional conferences, such as by the Mid-Atlantic Chapter (https://www.esa.org/midatlantic/). These may be especially valuable for contingent faculty, as they can provide affordable networking and professional development opportunities.

The allocation of funds to support research is highly competitive and since contingent faculty are often ineligible to apply for internal funds, their access to support for research is often restricted. Consequently, they may be forced to subsidize their research with private resources or to discontinue research altogether. By encouraging academic institutions to recognize contingent status as a career stage arising from systemic issues, they might be able to ameliorate this situation. It is increasingly important for both academic institutions and professional societies to legitimize and support the professional development of academic faculty through multiple career stages, as well as alternative professional pathways. This is captured in the European Charter for Researchers and Code of Conduct for

the Recruitment of Researchers (European Commission 2005): “Employers and/or funders of researchers should draw up, preferably within the framework of their human resources management, a specific career development strategy for researchers at all stages of their career regardless of their contractual situation, including researchers on fixed-term contracts.”

Respondents’ comments

In the final open-ended question, respondents, including postdoctoral fellows, provided 105 comments and suggestions for other activities that would help them professionally, covering a broad range of concerns. An overall impression of their comments can be found in Fig. 3. Notably, several respondents were concerned with the perception and treatment of contingent faculty as second-class citizens: Some criticized the survey for appearing to support this view, while others expressed their gratitude for the survey. One suggested remedy would be to recognize alternative career stages in science by formalizing the role of contingent faculty as instructors or research scientists (see, e.g., Rohn 2011), leading to more equitable pay, treatment, and work conditions. Another avenue suggested was to create unions for contingent faculty to protect their rights with fair treatment and benefits. Both put the onus on academic institutions to recognize and better support the faculty that they are increasingly hiring to teach and do research in contingent, non-tenure-track positions. Another repeated suggestion was for institutions to create more permanent full-time, tenure-track faculty positions and to offer guidance for pathways from contingent to tenure-track positions. Echoed throughout was the need to change institutional structures to reflect the current reality of its workforce, with contingent faculty now constituting the majority of the academic workforce in the United States and in other countries.

Another recurring theme was the importance for ecologists and institutions to be more inclusive in recognizing the diversity of career paths, particularly non-traditional ones, for this burgeoning mid-career constituency. Some ecologists choose to work in contingent positions for the flexibility offered, while others become contingent for family and other reasons. So, contingent faculty constitute a heterogeneous group within academia, with some permanently and others temporarily contingent, some by choice and others by circumstance. Contingent faculty often are stigmatized and without institutional support, while academia focuses on and grants privileges to tenured and tenure-track (i.e., salaried) faculty and early-career scholars. If academia is to make the best use of its talent, this mismatch between institutional priorities and the

Fig. 3. Wordle diagram based on respondents’ comments received in the survey of contingent faculty in ecology. To generate the diagram, “faculty” and “contingent” were eliminated and “teach” was combined with “teaching.” The responses of postdoctoral fellows were combined with those of contingent faculty.

majority of its human resources needs to be addressed (Childress 2019).

Other comments reinforced the professional development activities outlined in the earlier questions, including the following: reduced fees for membership, publications, and meetings; online access to journals; travel grants; and increased opportunities for research collaboration, networking, and career mentoring. Respondents called for broader skills training and more attention to non-academic career pathways. The teaching group's needs focused on access to teaching resources, courses, and workshops, particularly online or with a mentor. They requested skills training for how to integrate teaching into research and vice versa and how to teach difficult ecological concepts, ecology for non-science majors, and in non-traditional settings, such as music and art schools. Meanwhile, the research group cited institutional barriers that prevent them from being able to serve as principal investigators on grants, to apply for research funding as non-tenure-track faculty, and to supervise graduate students. They also requested advice on the specific challenges of writing proposals to the National Science Foundation (NSF) and other agencies while occupying a contingent position, given the impact of budgeting for their own salary compared with their salaried counterparts. Some encouraged ESA to advocate for increased research funding among policymakers, which ESA, as part of a coalition of scientific societies, already does.

Conclusions

Contingent or non-tenure-track faculty constitute nearly 70% of the academic workforce in the United States. They typically have lower pay, less job security, and reduced or nonexistent health benefits compared with their salaried tenured and tenure-track counterparts (GAO 2017). The impacts of this growing institutional trend to hire non-tenure-track, often part-time faculty, such as adjunct professors and lecturers, were examined in relation to contingent faculty demographic and career profiles. An ESA survey of contingent faculty in ecology (n = 536) was compared with a CAW survey of contingent faculty in STEM (n = 2915), which revealed that respondents to the ESA survey were more likely to have full-time positions, to be employed in research, and to remain contingent for shorter periods of time than respondents to the CAW survey, who were more often employed part-time to teach, sometimes for their entire careers. In contrast to the typical overrepresentation of women in STEM contingent faculty positions, respondents to the ecology survey were almost equally divided between women and men, reflecting the gender parity in doctorates awarded in ecology in recent years. They constitute a heterogeneous group within academia, with some permanently and others temporarily contingent, some contingent by choice and others by circumstance. They often have non-traditional, interdisciplinary, or action-oriented career paths, but yet provide the bulk of teaching and research services in academia today.

Despite their numbers and contributions to higher education and research, contingent faculty experience inequitable pay, treatment, and work conditions compared with their tenured and tenure-track peers. They want institutional recognition and support in their career development, which can come by altering career structures in academia and formalizing the role of contingent faculty as permanent instructors or research scientists. ESA can better support contingent faculty by providing reduced fees for memberships, page charges, and conferences; small grants for research and travel; online access to journals; and support for teaching-related activities. Professional societies, such as the ESA, and academic institutions should recognize contingent faculty as a career stage and support the professional development of academic faculty through multiple and diverse career stages and pathways. This would avert unnecessary loss of trained talent from the academy.

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Supporting Information

Additional Supporting Information may be found online at: http://onlinelibrary.wiley.com/doi/10.1002/ecs2.2964/full