



A response to Lockwood, Reiners, and Reiners

Lockwood *et al.* (*Front Ecol Environ* 2013; 11[4]: 188–93) tackle an important state-of-the-field question: how do ecological work and work-related satisfaction track across gender and age categories? However, several aspects of their design and analysis appear to be flawed:

- (1) The study design assumes that sources of satisfaction are stable over time and across positions, roles, and circumstances. This assumption is not testable with the available data. Furthermore, predicting that there will be a consistent mismatch between job activities and satisfaction over a scientist's lifetime relies on an inappropriate extrapolation of the available data.
- (2) The authors assume (a) that there are only two true "yes" states for job satisfaction per respondent, which is not a meaningful binary outcome and (b) a "non-yes" state automatically equates to a "no" state (eg no job satisfaction), when in fact the response does not represent an authentic binary state (ie "heads or tails?"). This raises validity questions because the survey does not appropriately represent the construct being investigated.
- (3) Job *satisfaction* responses are invalidly interpreted in terms of job *performance*. Because a (slightly) higher proportion of men than women report satisfaction from data analysis, the authors suggest women struggle with math. Similarly, a (slightly) higher proportion of women stating that they derive satisfaction from teaching is interpreted to reflect a lack of interest/ability in research, a hypothesis not testable with these data.

The authors also developed numerous regression models without addressing the potential for Type I error or reporting a correction procedure. Thus, Lockwood *et al.*'s Table 1

likely reflects numerous false positives. Furthermore, they do not report exact *P* values and effect sizes for the individual statistical tests. Lockwood *et al.* may have identified a limited number of gender differences between ecologists but failed to recognize strong patterns of similarity across genders. A re-examination of their data on sources of job satisfaction finds strong congruence in the activities that provide satisfaction for all ecologists. Notably, the top two sources of satisfaction for each gender are field work and data analysis (Table 1).

Furthermore, with statements such as "Although women undoubtedly can master mathematical skills", "...women find mathematical thinking less satisfying, and our results would support this interpretation", and "Perhaps ... the fact that research-intensive universities average fewer women on the STEM faculty than other academic institutions reflect[s] women's predilection for

teaching as a source of fulfillment", it would be unsurprising if readers perceive Lockwood *et al.* as supporting negative stereotypes about the interests and abilities of female scientists, even though such conclusions cannot be drawn from the data available, as we have outlined above. Further, Lockwood *et al.* highlight studies that point out achievement differences by gender, while apparently overlooking well-documented evidence of biases that create barriers for women in science. For example, recent work found that both male and female faculty rated a job applicant as more competent if the name was "John" rather than "Jennifer" on otherwise identical curricula vitae (Moss-Racusin *et al.* 2012). Evidence for gender bias in manuscript reviews emerges from a 7.9% increase in articles by female authors following the introduction of double-blind review in the journal *Behavioral Ecology* (Budden *et al.* 2007).

Upholding exacting standards for

Table 1. Pattern similarity of professional satisfaction by gender*

	Male count	Response percentage and rank order	Female count	Response percentage and rank order
Field work	401	25.59 1	208	27.66 1
Experiments	145	9.25 5	69	9.18 6
Data analysis	337	21.51 2	121	16.09 2
Written communication	206	13.15 3	73	9.71 5
Oral communication	88	5.62 7	55	7.31 7
Classroom teaching	108	6.89 6	80	10.64 4
Individual teaching	169	10.78 4	97	12.90 3
Management	68	4.34 8	32	4.26 8
Other	45	2.87 9	17	2.26 9
Sum of responses	1567		752	

Notes: Bold values indicate rank-order match. Red values are the top two choices and blue indicates the three lowest-ranked tasks for both male and female ecologists. *A note on differences between percentages reported here and in Lockwood *et al.*: we report percentages based on response totals rather than participant totals. We did this because, based on the numbers provided by Lockwood *et al.*, we assume that not all respondents chose two satisfaction elements from the survey list (eg the total number of responses does not add up to twice the number of survey respondents as would be expected). Here, counts are the number of responses reported in each category for each gender; respondents were allowed to pick two elements that provided job satisfaction. Response totals are the percentage of responses for each category out of the total number of responses. Thus, our percentage values are roughly one-half as large as those reported by Lockwood *et al.* The data presented here are taken from WebTable 6 in Lockwood *et al.*

analyzing and interpreting data is vital in ecological research, and maintaining these standards is even more important when research results pertain to human attributes. Policy affecting how we attract and retain scientists is influenced by research such as that carried out by Lockwood *et al.* We welcome research on how different groups within science perceive their jobs and can be best supported, but it is critical that this research meets the highest standards for design, analysis, and interpretation. To advance a solid understanding of both similarities and differences between male and female ecologists, we advocate the development of more rigorous survey methods and statistical analyses prior to interpretation of how those differences may affect job performance.

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Budden AE, Tregenza T, Aarssen LW, *et al.* 2007. Double-blind review favours increased representation of female authors. *Trends Ecol Evol* 23: 4–6.

Moss-Racusin CA, Dovidio JF, Brescoll VL, *et al.* 2012. Science faculty's subtle gender biases favor male students. *P Natl Acad Sci USA* 109: 16474–79.

doi:10.1890/13.WB.018



The authors' reply

We thank Throop *et al.* for their insights, readily admitting that our study of the complex issues of age and gender in science is “flawed” insofar as empirical research provides only partial truths. However, knowing something about the sociology of science is surely better than having no data or relying on anecdotal information. As for their particular concerns, we offer the following.

Throop *et al.* contend that we assume ecologists' professional satisfaction is stable and this is not testable with available data. We do make this assumption, and they are correct in that no longitudinal data exist (perhaps our initial article will stimulate such a long-term study with the same cohort). And despite the hazards of induction, this is oftentimes the only reasonable strategy (eg climate-change research frequently entails temporal extrapolation).

They frame our survey as offering binary choices, which is a misunderstanding. In fact, we offered several choices and then limited responses to two affirmations (the options were not “yes, I like this” and “no, I don't like this”). We used nine logistic regressions to identify whether or not a category was a primary source of job satisfaction. In using binary regression, we do not suppose that the less favored options were viewed negatively by respondents, as Throop *et al.* suggest. We asked which aspects of professional activity provided the *most* personal satisfaction. Our question simply and validly assumed ordinal preferences. By analogy, if a person selects strawberry and vanilla as their favorite flavors from a list of 10 options, it would be mistaken to assume that the individual is repulsed by or even does not like cherry, butterscotch, or the other flavors.

We are accused of claiming that women “struggle with math” (a phrase we never used); in fact, we explicitly state that “women undoubtedly can master mathematical skills”. It is inferred that we also equate satisfaction with performance, which is unexpected, given that many humans excel in unsatisfying tasks. We did, however, say that certain preferences were mismatched to rewards, which is demonstrably true for males and females. Moreover, women's higher preference for teaching is not our “interpretation”, as suggested by Throop *et al.*; it is an empirical finding.

Our decision to exclude *P* values was based on a preference for sim-

licity and can be justifiably criticized. Whether (and what type of) a correction procedure is used, however, depends on the purpose of the analysis. Ours was exploratory rather than confirmatory; in the latter type of analysis, it is more typical to adjust for inflated errors. That being said, we have amended the original WebTables to include two tables with both *P* values and effect sizes (WebTables 1 and 2 associated with this letter). However, even after adopting the strictest experiment-wide Bonferroni correction ($P < 0.0016$), our results still yield several statistically significant gender effects along with practically informative effect sizes.

Throop *et al.* are right about there being strong congruence in the activities that provide satisfaction for all ecologists, but there are still statistical differences in what males and females find to be *most* rewarding. The strict space limits of *Frontiers* precluded us from presenting the full range of potential analyses, so we welcome additional efforts in this regard. We appreciate our critics' analyses and note that their own results affirmed a strong, gender-based difference with regard to the satisfaction derived from written communication and classroom teaching.

We would note that Throop *et al.*'s analysis was based on data from our WebTables. We mistakenly indicated that these were age-truncated data; the table actually includes data from all ages. We apologize for this oversight but note that there are no substantive differences in the results based on either parsing of the data.

Furthermore, Throop *et al.* interpret our work as supporting negative stereotypes of female scientists, but perhaps this is an example of the theory-laden nature of observations (or reading). They also move from the empirically sound claim that men and women have different preferences to the assertion that such a difference connotes a better/worse distinction, and we do not make this unfounded supposition in our paper. Instead, we note that the American Association of University Women