

## The phantom chorus: birdsong boosts human well-being in protected areas

Danielle Ferraro, Zachary D. Miller, Lauren A. Ferguson, B. Derrick Taff, Jesse R. Barber, Peter Newman and Clinton D. Francis

### Article citation details

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### Review timeline

Original submission: 27 July 2020  
1st revised submission: 30 September 2020  
2nd revised submission: 23 October 2020  
Final acceptance: 23 October 2020

Note: Reports are unedited and appear as submitted by the referee. The review history appears in chronological order.

## Review History

### RSPB-2020-1811.R0 (Original submission)

#### Review form: Reviewer 1

##### Recommendation

Accept with minor revision (please list in comments)

##### Scientific importance: Is the manuscript an original and important contribution to its field?

Excellent

##### General interest: Is the paper of sufficient general interest?

Excellent

##### Quality of the paper: Is the overall quality of the paper suitable?

Excellent

##### Is the length of the paper justified?

Yes

##### Should the paper be seen by a specialist statistical reviewer?

No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**

No

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**

Yes

**Is it clear?**

Yes

**Is it adequate?**

Yes

**Do you have any ethical concerns with this paper?**

No

### **Comments to the Author**

This is an interesting paper that experimentally investigates the effects of birdsong on human psychological health (self-reported well-being) in protected areas. The authors found that increased birdsong has a positive impact on human well-being in two trails. They also explored the psychological mechanisms underlying this relationship. The introduction is well-written; the field survey and statistical analysis were conducted carefully; the results are clear; and the findings were well discussed. I think this paper should be published in Proceedings B as the topic of the paper is very timely and has some important implications for conservation as the authors discussed. I only have several minor comments.

General question: In this paper, the authors investigated the impact of bird calls on human wellbeing by experimentally increasing the number of birdsongs in protected areas. If my understanding is correct, the environment condition in these protected areas is already ecologically good? If so, the environment with an abundance of birdsong they created in their experiment seems to be an unrealistic environment. How much sense does it make to measure the ecosystem services of these unrealistic environments?

Lines 47-48: It might be good to provide evidence showing that people in developed countries and regions spend much of their time indoors.

Lines 52-53: Nature also provide social health benefits to humans (e.g. increased social cohesion).

Lines 86-87: Fuller et al. (2007) (Reference 8) did not report that actual and perceived species richness of birds are correlated.

Lines 393-395: I am not familiar with the parks studied by the authors. Is it likely that park visitors' familiarity with nature (birds) varies between the two parks? Park visitors who are more knowledgeable about nature are more likely to perceive increased birdsong.

## **Review form: Reviewer 2**

### **Recommendation**

Accept with minor revision (please list in comments)

**Scientific importance: Is the manuscript an original and important contribution to its field?**  
Good

**General interest: Is the paper of sufficient general interest?**  
Excellent

**Quality of the paper: Is the overall quality of the paper suitable?**  
Excellent

**Is the length of the paper justified?**  
Yes

**Should the paper be seen by a specialist statistical reviewer?**  
No

**Do you have any concerns about statistical analyses in this paper? If so, please specify them explicitly in your report.**  
No

**It is a condition of publication that authors make their supporting data, code and materials available - either as supplementary material or hosted in an external repository. Please rate, if applicable, the supporting data on the following criteria.**

**Is it accessible?**  
Yes

**Is it clear?**  
Yes

**Is it adequate?**  
Yes

**Do you have any ethical concerns with this paper?**  
No

#### **Comments to the Author**

Thank you for this paper - I believe it is a contribution to the field and should be published after minor revisions.

## **Decision letter (RSPB-2020-1811.R0)**

10-Sep-2020

Dear Dr Francis:

Your manuscript has now been peer reviewed and the reviews have been assessed by an Associate Editor. The reviewers' comments (not including confidential comments to the Editor) and the comments from the Associate Editor are included at the end of this email for your reference. As you will see, the reviewers and the Editors have raised some concerns with your manuscript and we would like to invite you to revise your manuscript to address them. These reviews are detailed in the comments, below. In particular, when writing your Discussion, please be sure that the conclusions that you draw match the strength of your results.

We do not allow multiple rounds of revision so we urge you to make every effort to fully address all of the comments at this stage. If deemed necessary by the Associate Editor, your manuscript will be sent back to one or more of the original reviewers for assessment. If the original reviewers are not available we may invite new reviewers. Please note that we cannot guarantee eventual acceptance of your manuscript at this stage.

To submit your revision please log into <http://mc.manuscriptcentral.com/prsb> and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions", click on "Create a Revision". Your manuscript number has been appended to denote a revision.

When submitting your revision please upload a file under "Response to Referees" - in the "File Upload" section. This should document, point by point, how you have responded to the reviewers' and Editors' comments, and the adjustments you have made to the manuscript. We require a copy of the manuscript with revisions made since the previous version marked as 'tracked changes' to be included in the 'response to referees' document.

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[http://datadryad.org/submit?journalID=RSPB&manu=\(Document not available\)](http://datadryad.org/submit?journalID=RSPB&manu=(Document not available)), which will take you to your unique entry in the Dryad repository.

If you have already submitted your data to dryad you can make any necessary revisions to your dataset by following the above link.

For more information please see our open data policy <http://royalsocietypublishing.org/data-sharing>.

#### Electronic supplementary material:

All supplementary materials accompanying an accepted article will be treated as in their final form. They will be published alongside the paper on the journal website and posted on the online figshare repository. Files on figshare will be made available approximately one week before the accompanying article so that the supplementary material can be attributed a unique DOI. Please try to submit all supplementary material as a single file.

Online supplementary material will also carry the title and description provided during submission, so please ensure these are accurate and informative. Note that the Royal Society will not edit or typeset supplementary material and it will be hosted as provided. Please ensure that the supplementary material includes the paper details (authors, title, journal name, article DOI). Your article DOI will be 10.1098/rspb.[paper ID in form xxxx.xxxx e.g. 10.1098/rspb.2016.0049].

Please submit a copy of your revised paper within three weeks. If we do not hear from you within this time your manuscript will be rejected. If you are unable to meet this deadline please let us know as soon as possible, as we may be able to grant a short extension.

Thank you for submitting your manuscript to Proceedings B; we look forward to receiving your revision. If you have any questions at all, please do not hesitate to get in touch.

Best wishes,  
Dr Sarah Brosnan  
Editor, Proceedings B  
mailto:proceedingsb@royalsociety.org

#### Associate Editor Comments to Author:

The reviewers of this paper were positive, suggesting fairly minor revisions. One reviewer requests more discussion of the connection between the experimental protocol and natural conditions. The other reviewer suggests that the conclusions should be a bit more circumspect to better fit the results. Both make additional suggestions for clarity. I believe that these comments can be addressed through revision.

#### Reviewer(s)' Comments to Author:

Referee: 1

#### Comments to the Author(s)

This is an interesting paper that experimentally investigates the effects of birdsong on human psychological health (self-reported well-being) in protected areas. The authors found that increased birdsong has a positive impact on human well-being in two trials. They also explored the psychological mechanisms underlying this relationship. The introduction is well-written; the field survey and statistical analysis were conducted carefully; the results are clear; and the findings were well discussed. I think this paper should be published in Proceedings B as the topic of the paper is very timely and has some important implications for conservation as the authors discussed. I only have several minor comments.

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Lines 86-87: Fuller et al. (2007) (Reference 8) did not report that actual and perceived species richness of birds are correlated.

Lines 393-395: I am not familiar with the parks studied by the authors. Is it likely that park visitors' familiarity with nature (birds) varies between the two parks? Park visitors who are more knowledgeable about nature are more likely to perceive increased birdsong.

Referee: 2

Comments to the Author(s)

Thank you for this paper - I believe it is a contribution to the field and should be published after minor revisions.

## Author's Response to Decision Letter for (RSPB-2020-1811.R0)

See Appendix A.

## Decision letter (RSPB-2020-1811.R1)

23-Oct-2020

Dear Dr Francis

I am pleased to inform you that your Review manuscript RSPB-2020-1811.R1 entitled "The phantom chorus: birdsong boosts human well-being in protected areas" has been accepted for publication in Proceedings B.

The AE recommends only a minor change to your figures to improve clarity. I agree that as it stands it is too small to read, and worry that while it is distinctive enough in color that it functions almost as an icon, obviously linking back to Fig2, in black and white (i.e., printed out) that may not be the case. However, I leave it to you to decide which you prefer. Aside from this, please proof-read your manuscript carefully and upload your final files for publication. Because the schedule for publication is very tight, it is a condition of publication that you submit the revised version of your manuscript within 7 days. If you do not think you will be able to meet this date please let me know immediately.

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- 3) Electronic supplementary material: this should be contained in a separate file from the main text and the file name should contain the author's name and journal name, e.g. `authorname_procb_ESM_figures.pdf`

All supplementary materials accompanying an accepted article will be treated as in their final form. They will be published alongside the paper on the journal website and posted on the online figshare repository. Files on figshare will be made available approximately one week before the accompanying article so that the supplementary material can be attributed a unique DOI. Please see: <https://royalsociety.org/journals/authors/author-guidelines/>

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If you have already submitted your data to dryad you can make any necessary revisions to your dataset by following the above link.

- 5) For more information on our Licence to Publish, Open Access, Cover images and Media summaries, please visit <https://royalsociety.org/journals/authors/author-guidelines/>.

Once again, thank you for submitting your manuscript to Proceedings B and I look forward to receiving your final version. If you have any questions at all, please do not hesitate to get in touch.

Sincerely,

Prof Sarah Brosnan

Editor, Proceedings B

<mailto:proceedingsb@royalsociety.org>

Associate Editor

Comments to Author:

The changes suggested by the referees were minor and focused on presentation of the results and background literature. The authors have addressed the concerns thoroughly and thoughtfully in their revision.

My only comment is about the new Figure 3. This figure combines the graphic from Figure 2, depicting the birds of the phantom chorus, and the SEM statistics. The phantom chorus diagram

is reduced to a size too small to read, and it is redundant with Figure 2. I recommend replacing the cluster of circles with a single circle labelled "phantom chorus". This is how it was presented in the prior versions of Figure 3 and 4.

## Decision letter (RSPB-2020-1811.R2)

23-Oct-2020

Dear Dr Francis

I am pleased to inform you that your manuscript entitled "The phantom chorus: birdsong boosts human well-being in protected areas" has been accepted for publication in Proceedings B.

You can expect to receive a proof of your article from our Production office in due course, please check your spam filter if you do not receive it. PLEASE NOTE: you will be given the exact page length of your paper which may be different from the estimation from Editorial and you may be asked to reduce your paper if it goes over the 10 page limit.

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Thank you for your fine contribution. On behalf of the Editors of the Proceedings B, we look forward to your continued contributions to the Journal.

Sincerely,  
Proceedings B  
<mailto:proceedingsb@royalsociety.org>

## Appendix A

Dear Dr. Sarah Brosnan,

Please find our resubmission of manuscript number #RSPB-2020-1811 “The phantom chorus: birdsong boosts human well-being in protected areas.” We were pleased to receive quite positive reviews from both referees. The insightful suggestions of both reviewers have significantly improved the manuscript. We list the major changes in the revised version and we also provide point-by-point responses to each reviewer comment below. We hope you find these changes satisfactory for publication of our manuscript in *Proceedings B*.

### Major Changes:

1. We have thoroughly revised our discussion in response to reviewer 2’s suggestion and the associate editor’s request that we are more circumspect about our results, especially the role of perceived biodiversity. We now also provide a thorough discussion of how the documented effect was small, but in the context of the study design and how it compares to other experimental studies focused on improvements in well-being in response to nature experiences.
2. As recommended by the associate editor and reviewer 1, we have revised the description of our experimental protocol to clearly convey that our experimental playback created audible birdsong typical of real natural areas by conducting our study later in the summer when singing is far less common. In essence, we recreated the level of birdsong typical to earlier in the breeding season.
3. We have revised our description of operationalizing environmental restoration theory by clearly articulating which prior research involving acoustics has served as a foundation for use in our study.
4. We now explicitly address the implication raised by reviewer 2 that fake birdsong could pave the way for relying on imitations of nature at the expense of engaging in real experiences with nature.
5. To adequately incorporate the reviewer suggestions through additional text, we have also combined figure 3 and 4 from the previous version into a single figure, which is now figure 3.

We look forward to hearing from you.

Best wishes,

Clinton Francis (on behalf of all authors)

## Point-by-point responses:

Associate Editor

Comments to Author:

The reviewers of this paper were positive, suggesting fairly minor revisions. One reviewer requests more discussion of the connection between the experimental protocol and natural conditions. The other reviewer suggests that the conclusions should be a bit more circumspect to better fit the results. Both make additional suggestions for clarity. I believe that these comments can be addressed through revision.

(1) Response: We were very pleased to receive the positive and constructive feedback from both reviewers and the associate editor. Please see our responses below. In brief, we believe the comments and requested changes have improved the manuscript considerably.

Reviewer(s)' Comments to Author:

Referee: 1

Comments to the Author(s)

This is an interesting paper that experimentally investigates the effects of birdsong on human psychological health (self-reported well-being) in protected areas. The authors found that increased birdsong has a positive impact on human well-being in two trails. They also explored the psychological mechanisms underlying this relationship. The introduction is well-written; the field survey and statistical analysis were conducted carefully; the results are clear; and the findings were well discussed. I think this paper should be published in Proceedings B as the topic of the paper is very timely and has some important implications for conservation as the authors discussed. I only have several minor comments.

(2) Response: We appreciate the positive synopsis.

General question: In this paper, the authors investigated the impact of bird calls on human wellbeing by experimentally increasing the number of birdsongs in protected areas. If my understanding is correct, the environment condition in these protected areas is already ecologically good? If so, the environment with an abundance of birdsong they creased in their experiment seems to be an unrealistic environment. How

much sense does it make to measure the ecosystem services of these unrealistic environments?

(3) Response: This is a very good point that we see warrants additional explanation for a broad readership. The key here is that the timing of our experiment coincides with lower singing activity. That is, we conducted the experiment after birds have finished nesting or overlapping the end of their breeding season. We were explicit in the previous version that this was done to minimize problems associated with simulating territorial intrusions for breeding individuals, but it also was carried out at this time so that we could elevate bird song activity from relatively low levels to something more typical of the beginning of the breeding season when male birds sing to attract mates and defend territories.

We now clarify in the manuscript that conducting our study at this time in the breeding season allowed us to effectively contrast exposure to bird song that is typical of earlier in the season with conditions with little bird song.

Lines 47-48: It might be good to provide evidence showing that people in developed countries and regions spend much of their time indoors.

(4) Response: Thanks for the suggestion. We have added a passage that provides additional evidence for how much time the typical US citizen spends indoors.

Lines 52-53: Nature also provide social health benefits to humans (e.g. increased social cohesion).

(5) Response: We have modified this section to incorporate these benefits as well.

Lines 86-87: Fuller et al. (2007) (Reference 8) did not report that actual and perceived species richness of birds are correlated.

(6) Response: The reviewer is correct. Fuller et al. (2007) did not find a statistically significant (at  $\alpha = 0.05$ ) relationship between perceived species richness and actual species richness. However, the relationship between perceived plant richness and sampled plant richness was

strongly and significantly correlated and the relationship with birds was marginally non-significant, but with fairly high correlation coefficient ( $r = 0.49$ ,  $p = 0.066$ ). There are many schools of thought on analyses and thresholds for inference. In our opinion, this apparent trend warrants consideration. Nevertheless, we have modified this statement to more accurately reflect the specifics of the study.

Lines 393-395: I am not familiar with the parks studied by the authors. Is it likely that park visitors' familiarity with nature (birds) varies between the two parks? Park visitors who are more knowledgeable about nature are more likely to perceive increased birdsong.

(7) Response: We have revised our wording in the introduction to be clear that we only worked in a single park (Boulder Open Space and Mountain Parks), but that we worked on two different trails within this park system. We had also anticipated that birding experience could influence the outcomes of our study, as such we asked visitors three questions about their birding experience towards the end of the survey. The question was “Do you participate in birding?” with possible answers being “yes” or “no.”

Approximately 15% of the sample responded that they did participate in birding. In preliminary analyses, we tested the effect of birding on perceived restoration, plus sound coherence, sound fascination and sound compatibility. Each model also included perceived biodiversity, trail ID, phantom chorus (On/Off) and an interaction between trail ID and phantom chorus. In one version, we used linear models with ordinal study day as an additional predictor. In other versions, we used study day OR study week as factors for inclusion as random intercepts in mixed-effect models. There was no indication that birding had an influence on perceived restoration, sound coherence, sound fascination or sound compatibility. Given this outcome, we did not include self-identification as a birder in any of the formal analyses.

Comments to the Author(s)

Thank you for this paper - I believe it is a contribution to the field and should be published after minor revisions.

(8) Response: We were happy to learn that the reviewer was quite positive about the manuscript.

Overall, I recommend this paper be revised and resubmitted. I commend the authors for attempting an experimental design in an outdoor setting. While it has certainly been done, it is difficult to do well. I also appreciate the literature contribution, linking mental health to nature experiences – however with the mixed findings presented here – I have trouble with some of the strong assertions made about the results. I also will need to be convinced about the theoretical underpinnings, where restorative environments was measured based on auditory contexts only. I also fear that experimental designs using recorded or fake natural sounds may lead us down a slippery slope of relying on recorded or virtual nature to dominate or real interactions with nature. See general comments below followed by a table with specific line-by-line feedback.

(9) Response: First, we are happy to receive the feedback about attempting this project in the field. This project was certainly a challenge!

We reply to some of the issues raised in more detail below. Briefly, we can say that we have revised the manuscript as suggested to better reflect the mixed findings. We have also added additional justification for the theoretical underpinnings for restorative concepts in the auditory context.

Finally, the comment about the “slippery slope” of using recorded sounds rather than real experiences with nature is important. This is something that our research group has thought about and debated at length and we had chosen to not explicitly address this issue in the manuscript. In reality, natural sounds are already used to “enhance” experiences in restaurants, spa resorts and even zoos. We are not aware of any published findings on their effectiveness, but we believe the work published here and that of others in our group is beginning to suggest that broadcasts of these sounds could have measurable influences on visitor/customer experiences. Given the reviewer’s worry, we have changed our minds and now explicitly address this issue in the discussion and emphasize that we should collectively resist the temptation to substitute real natural

experiences with copies of it. Nature experiences are not unimodal and we have a lot to learn about how information from multiple modalities are integrated and lead to overall experiences with nature and potential health and psychological benefits.

#### Key Concerns:

Your operationalization of environmental restoration theory needs further justification. I am not familiar with literature that parcels out certain environmental aspects (e.g., sound, air quality, scenery) and measures coherence, fascination and compatibility based on one environmental component. This may very well be by lack of familiarity with operationalizing the theory, but I would like to see some examples in the literature or justification for this approach for those like me who are only somewhat familiar.

- (10) Response: Of most salience to our article was Payne's (2013) work that operationalized measures of psychological restoration in relation to soundscapes. This approach isolates perceived restorativeness of the acoustic environment as opposed to the experiences. These scales perceptions of a soundscape's potential to provide psychological restoration. There are many, many measures of human well-being, and we felt this one was the most appropriate for our study since it was so soundscape focused.

Most of my specific comments have to do with your conclusions and discussion feeling somewhat misaligned with your results. It seems to me that your discussion is an attempt to stretch your findings into something that you only found at one site, and with a small effect. Rather, the discussion should be framed to reflect the results that you actually found – which was mixed. Please see my specific comments in the table to address some of this misalignment.

- (11) Response: As we mention above in response 9, in this revision we have made efforts to more accurately reflect the mixed results of our study.

It worries me a little bit that this experiment also shows that recorded or fake birdsong can have similar effects as natural birdsong. Does this lead us down a research path similar to virtual reality where we will simulate nature to make us feel better as a society

about depleting it? There is no reference to this potential in the paper, and I think there ought to be.

(12) Response: As mentioned in response 9, we now explicitly address this issue in the discussion.

P5: It might be helpful to include a trail map here. It isn't entirely clear to the unfamiliar reader why the treatments needed to be stratified so as not to impact one another. Make proximity more clear.

(13) Response: Perhaps the reviewer missed figure 1 panels a and b, which we reference on this page? Additionally, we have reworded the passage describing why we alternated playback of the phantom chorus between trails for clarity. Essentially, this was completed to help control for the influence of factors that could influence visitor responses on both trails at the same time, such as weather. That is, hypothetically speaking, if an extremely hot day had a latent effect on how visitors responded, had the phantom choruses been on simultaneously, the latent effect of the hot day would coincide completely with the phantom chorus being on or off. With the chorus alternating between trails, this latent effect would be captured across both treatment categories.

P7 - line 152: Why are you indicating that you want to reach more non-local users? Don't you want a representative sample? This strategy needs to be clarified, especially since it is mentioned as an explanation and limitation to your results later in the manuscript (Sample characteristics, p. 13, lines 293-296 and p. 16)

(14) Response: We have added additional context to this passage and have revised the discussion to better address sample characteristics. We certainly sampled many local users with 41% of our users living within the county (Table S4). However, we believe capturing more visitors from elsewhere in Colorado or the US should provide a more generalizable population than one with even more local users.



P 14 - line 314-315: Please provide justification (maybe in a lit review?) for using restoration measures based on audition only – I have not seen this scale applied to aspects of the environment in this way so am curious about precedent for this approach. Especially given that some factor loadings appear to be quite low.

(15) Response: Please see response number 10 above where we describe how we have modified the manuscript in response to this comment about the application of environmental restoration theory to audition.

Regarding the comment that some factor loadings were low. This comment allowed us to catch an error in a previous version of the CFA figure (supplement) with a low factor loading for sound compatibility (0.54). It was actually 0.95 and we have corrected this in an updated figure.

P 16 - line 360-361: This statement seems to suggest that the study trails or sampling strategy, not a potential weak relationship, is the reason for different findings across sites. Couldn't another potential reason be the study attributes and perhaps not finding what was expected?

(16) Response: We have added text here and elsewhere in the discussion to more thoroughly address the weak relationship.

P 16-17: line 365-367: This sentence feels too absolute. It would read more convincingly if you said something like "...increases in visitor perceptions of bird species diversity would *contribute* to perceived psychological restoration..." rather than that it may be *necessary*. Avoid such absolutes.

(17) Response: We have made the suggested change.

P 17-18 generally: Similar to comment above - this is a good discussion in regards to the differences in results you found between trails, but you never quite come out and say that your results also indicate that perceived biodiversity may not have an effect – given that it did not at both sites and not a strong effect at either site. You automatically attribute the differences in findings to differences in trail characteristics or study population – but what about your study variables?

(18) Response: We have revised the discussion to acknowledge that our results are quite mixed with respect to the influence of perceived biodiversity on perceived restoration and now discuss how other study attributes may have influenced our results. We also acknowledge that the

< 10 minutes of exposure is quite brief. Future research seeking to understand the length of a nature experience and the size (and persistence) of benefits are needed.