

## Korespondensi Paper

**Judul** : Safeguarding imperilled biodiversity and evolutionary processes in the Wallacea center of endemism

**Jurnal** : Bioscience

| <b>No.</b> | <b>Aktivitas/Status</b> | <b>Tanggal</b>  | <b>Keterangan</b>                             |
|------------|-------------------------|-----------------|---|
| 1.         | Submission              | 21 Juni 2022    | Submitted Manuscript and Authorship Statement |
| 2.         | Decision                | 19 Juli 2022    | Editor's and Reviewers' Comments              |
| 3.         | Revision                | 17 Agustus 2022 | Cover Letter, Authors' Response               |
| 4.         | Uncorrected Proof       | 17 Agustus 2022 | Pre-publication                               |
| 5.         | Published online        | 19 Oktober 2022 | Available online (open access)                |

## Submitted Manuscript and Authorship Statement

### A. Submitted manuscript is available at:

[REVISION SUBMITTED - Dropbox](#)

Supplementary File is available at: [REVISION SUBMITTED - Dropbox](#)

### B. Authorship statement

#### **SAFEGUARDING IMPERILED BIODIVERSITY AND EVOLUTIONARY PROCESSES IN THE WALLACEA CENTER OF ENDEMISM**

Matthew Struebig and Sabhrina Aninta contributed equally as co-lead authors to this work.

Matthew Struebig (m.j.struebig@kent.ac.uk) is a Reader in Conservation Science, Zoe G. Davies is Professor of Biodiversity Conservation, Michaela Lo is a PhD student, and Simon Mitchell and Maria Voigt are postdoctoral researchers in biodiversity conservation at the Durrell Institute of Conservation and Ecology, University of Kent, UK. Sabhrina Gita Aninta (s.g.aninta@qmul.ac.uk) is a PhD student, Rosie Drinkwater is a molecular ecologist, Stephen J. Rossiter is a Professor in Molecular Ecology and Evolution, and Laurent Frantz is a Professor of Paleogenomics at Queen Mary University of London, UK. Maarten De Brauwer is a marine ecologist at CSIRO Oceans and Atmosphere, Hobart, Australia. Maria Beger is an Associate Professor in Conservation Science, and Molly McCannon a marine ecologist at University of Leeds, UK; Alessia Bani is a microbial ecologist and Alex Dumbrell is a Professor of Environmental Microbiology and Bioinformatics at University of Essex, UK. Henry Barus and Aiyen Tjoa are senior soil scientists in Tadulako University, Central Sulawesi, Indonesia. Selina Brace is Principal Researcher in Ancient DNA at the Natural History Museum, London, UK. Karen Diele is a Professor of Marine Ecology and Marco Fusi is a postdoctoral marine scientist at Edinburgh Napier University, UK. Cilun Djakiman is a genetic barcoding researcher and Gino Limmon a marine biologist at Pattimura University, Ambon, Indonesia. Rignolda Djamaluddin is a mangrove ecologist and Johnny Tasirin a Lecturer in Biogeography and Ecology in at Sam Ratulangi University, North Sulawesi, Indonesia. Darren Evans is a Professor of Ecology and Conservation at Newcastle University, UK. Leonel Herrera Alsina is a Research Fellow in Macroevolution, Lesley Lancaster is a Reader in Macroecology and Justin Travis is a Professor in Ecological and Evolutionary Modelling in Aberdeen University, UK. Djoko Iskandar is a Professor of Evolution and Biosystematics in Bandung Institute of Technology, West Java, Indonesia. Jamaluddin

Jompa is a Professor in Marine Ecology at Hasanuddin University, Sulawesi, Indonesia. Berry Juliandi is a Lecturer in Biology at Bogor Agricultural University, West Java, Indonesia. Lindawati is a Lecturer in Chemical Engineering at Surya University, West Java, Indonesia. Pungki Lupiyaningdyah is a researcher in biosystematics, Joeni Rahajoe, Rugayah and Himmah Rustiami researchers in plant ecology, and I Made Sudiana a researcher in Microbial Ecology at the National Research and Innovation Agency (BRIN), West Java, Indonesia. Erik Meijaard is a Professor of Conservation Science at Borneo Futures, Brunei. Sonny Mumbunan is an ecological economist, Nurul Winarni a Lecturer in Ornithology and Jatna Supriatna a Professor of Biology at University of Indonesia, West Java, Indonesia. Darren O'Connell is a molecular ecologist at University College Dublin, Ireland. Owen Osbourne is an evolutionary ecologist and Alex Papadopoulos a Senior Lecturer in Molecular Ecology at Bangor University, UK. Rosaria is a PhD student at University of Oxford, UK. Ulrich Salzmann is a Professor of Palaeoecology & Palaeoclimatology at Northumbria University, UK. Sheherazade is the Co-Executive Director of PROGRES, a Sulawesi-based NGO to initiate and empower locally-led conservation. Endang Sukara is Professor of Biodiversity, Microbiology and Bioethics in the National University, West Java, Indonesia. Liam Trethowan is a plant scientist and Tim Utteridge a Senior Research Leader in Taxonomy and Systematics at Royal Botanic Gardens Kew, UK. Agus Trianto is a Lecturer in Marine Environment and Natural Products at Diponegoro University, Central Java, Indonesia. Zulianto Zakaria is Lecturer in Biology at Gorontalo University, Sulawesi, Indonesia. David Edwards is a Professor of Conservation Science at University of Sheffield, UK.

## Editor's and Reviewers' Comments

**From:** BioScience <[onbehalf@manuscriptcentral.com](mailto:onbehalf@manuscriptcentral.com)>  
**Sent:** 19 July 2022 19:25  
**To:** Matthew Struebig <[M.J.Struebig@kent.ac.uk](mailto:M.J.Struebig@kent.ac.uk)>  
**Subject:** BioScience - Decision on Manuscript ID BIOS-22-0156

19-Jul-2022

Dear Dr. Struebig:

I am writing to you regarding Manuscript ID BIOS-22-0156 entitled "Safeguarding imperiled biodiversity and evolutionary processes in the Wallacea center of endemism," which you submitted to BioScience as a Forum article. Based on the comments from the reviewers and the recommendation of the Handling Editor I am requesting that you undertake a minor revision of your manuscript. The reviewers all agreed this was an interesting and valuable manuscript on a very important conservation challenge. The reviewers also offer a number of suggestions to help you improve flow and content that you should consider in a revision. The comments of the reviewers and Handling Editor are included at the bottom of this letter. I expect that we will be able to accept the manuscript for publication upon the satisfactory completion of these revisions.

### MS Content

Please detail your responses to reviewers' suggestions in the appropriate box. Do not place your response in the cover letter as this will not be visible to reviewers.

If you have supplementary materials that could benefit researchers, see [www.aibs.org/bioscience/authors\\_and\\_reviewers.html](http://www.aibs.org/bioscience/authors_and_reviewers.html) for details of permissible file formats. We will not edit supplementary material files, so please ensure you provide accurately edited files that conform to BioScience house style.

If you have placed your original submission on a publicly accessible Web site, please do not replace with the revised version but instead label it as the author (submitted) version.

Along with the title and complete list of authors names, affiliation (including the country for each affiliation), and contact information (again including the country), please include your abstract, any acknowledgments, and five keywords with your text as well as in the boxes on the submission form.

### Coauthor contributions

If you have not already done so, please upload as a supplementary file "not for review" an "Authorship Statement" that describes for each author his or her contribution to the article.

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the processing of the revised manuscript, please be as specific as possible in your response to the reviewer(s).

**IMPORTANT:** Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

Because we are trying to facilitate timely publication of manuscripts submitted to BioScience, your revised manuscript should be submitted by 09-Aug-2022. If it is not possible for you to submit your revision by this date, we may have to consider your paper as a new submission.

Once again, thank you for submitting your manuscript to BioScience and I look forward to receiving your revision.

Sincerely,

Scott L Collins  
Editor in Chief, BioScience  
Twitter: @AIBSbiology  
American Institute of Biological Sciences  
950 Herndon Parkway  
Suite 450  
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Handling Editor's Comments to Author:

Editorial Board Member  
Comments to the Author:  
Dear Dr Struebig,

We have now received three reports on your article from experts in the the field, and all three agree your article is a very timely and important contribution. All three have made minor suggestions that I would like to encourage you to consider in a revised version as I believe many of them will increase the impact of your article. We look forward getting your revised article.

Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author  
Comments (page numbers refer to the numbers in the lower right corner of page)

- This is an incredibly important subject, and I am very happy that the authors chose to address it. The difficulty in doing so is that the region has a very heterogeneous geological and evolutionary history. Different parts of Wallacea have very different floral and faunal communities, and even different climatic and oceanographic conditions, thus each region will need a tailored conservation approach.

- Very little attention is paid to why the marine fauna is so diverse compared to other tropical marine regions. For example, the Indonesian throughflow, or the consistent movement of water from the Pacific Ocean through Wallacea into the Indian Ocean, is a large reason why there are so many species present.

Page 5 line 2- "Wallacea archipelago" might be replaced by "archipelagos of Wallacea" as there are multiple distinct sets of islands within it.

Page 6 second line from bottom- should be Table S2 referring to the mammals, frogs, and plants.

Page 11- this line "Climate change also pushes terrestrial species outside of their thermal optima, changing phenology and seasonality that could drive transitions towards savanna (Siyum 2020), making tropical dry forest ecosystems of the Lesser Sunda islands (e.g. Sumba, Flores) particularly vulnerable." Does not make sense to me. Many of the areas on these islands are already savanna, and the species that live there already have adapted to large seasonal variation in rainfall. Maybe explain.

Page 11- this line "much of that movement on Wallacea's rugged and convoluted islands is expected to be upslope" fails to mention that there is much less standing water on the steep slopes of the mountains there. Many streams only run after rains and there are few lakes or ponds available. This will greatly restrict the set of species that can move upslope and persist.

Page 12-13- In many of the Lesser Sunda islands forest is not being cleared for agriculture, as the soil is too poor (e.g. Sumba, Sabu, Rote, Timor) and there is not enough water. Trees and any fallen wood are however collected as firewood and have huge effects on forest structure and the species present in the forest. This is my personal observation, but it might be discussed in the book "the ecology of nusa tenggara and maluku"

- Introduced species deserve a bit more attention. Much of the insular fauna of Wallacea is not ecologically competitive compared to continental taxa that become introduced. Some introduced species presumably have a small effect on the ecosystem, others have a measurable large negative effect (Asian Toads, Reilly et al. 2017), and even others could potentially be having a large negative effect but we don't know due to lack of data or complex ecological interactions (Asian Wolf Snakes, Reilly et al. 2019).

- Figure 2 is misleading for small range species in Lesser Sundas. A number of new papers on reptiles, amphibians, and terrestrial invertebrates are showing that many species spanning multiple islands or island clusters represent both cryptic and non-cryptic species complexes, and that the true biodiversity of these groups is much greater than thought. This also means that the range sizes of each true species is much smaller than that of the species complex's range.

Supp Table 1- 'Mobilism of Sunda taxa onto Sumba block 60 Mya' is not really correct. The plate fragment broke off then but was submerged for tens of millions of years before re-emerging and staying continuously emergent around 3-4 Ma (Fortuin et al. 1997). This later emergence is the geological information that is relevant for its

role in the accumulation of biodiversity, even regarding most shallow water marine species as it has rapidly risen from many kilometers deep.

Supp Table 1- 'mobilism of Sahul taxa following Timor-Banda collision 2.4 Mya' - Some recent studies are suggesting an older time of collision into Sahul Shelf of around 4 Ma (Nguyen et al. 2013).

Supp Table 1- 'Rifting of Australian continental margin ~100 Mya' – see above comment. This is not really correct or relevant. The continent-arc collision that created these islands began around 4-5 Ma, and for Babar and some of the smaller islands ages of 1-2 Ma are likely (Kaneko et al. 2007). These are the geological events of biotic significance.

Supp Table 2- There are many more papers than this. A comprehensive list is of course too large for this type of paper, but perhaps more than one example per taxonomic group is warranted.

Reviewer: 2

#### Comments to the Author

This manuscript could be considered a plea to the Indonesian government to utilize best conservation practices to protect the terrestrial and marine biodiversity of Wallacea, an imperiled tropical zone in Indonesia that supports exceptionally high levels of endemism as well as the complex evolutionary processes that led Alfred Wallace to establish the field of biogeography based on his studies in the region. This review is the end product of a workshop held by a large consortium of experts focused on the conservation of this critically important region.

The manuscript has several sections. The initial sections attempt to outline why Wallacea is interesting from the standpoint of its biogeography, evolutionary processes, and conservation. I think they did a decent job on the biogeography/evolutionary process front but it is difficult to be comprehensive in a few double-spaced pages so its best to think of their examples as vignettes. It might be worth their adjusting the text a bit to indicate that examples from the literature are referenced as a means of illustrating the types of interesting processes and systems that occur in Wallacea. For example, the discussion of the areas of endemism of Sulawesi showcases some of the notable examples from focal studies but certainly doesn't capture all that we know about species boundaries on this island. That's ok if presented as a series of vignettes rather than a comprehensive statement about diversification on this super complicated island.

The sections that followed were more focused on anthropogenic impacts and recommendations for protection and restoration of damaged ecosystems. This is not my research area, but I have the sense that these sections were more comprehensive and really focused on cutting-edge suggestions for moving forward. I learned a lot in reading these sections. The Box on mangrove restoration, for example, was very interesting and new to me.

I think the authors have a compelling argument to make. The author line includes



folks with prominent connections to higher branches of government who can use this document as a tool to enact change. The higher profile the venue of publication, the more likely they are to gain traction with their arguments. As such, I would love to see this piece appear in BioScience and be taken seriously by leaders in the Indonesian government.

I've added some comments directly on the MS where I think the text is misleading or where there might be factual errors. For example, one of my papers is cited as an example as "McGuire and Brown (2007)" when the paper actually has several other authors. I'll also point out – since I'm signing my review – that there are better discussions of the age of Lesser Sunda islands in papers published in the last few years on *Limnonectes* fanged frogs (Reilly et al. 2019) and *Draco* flying lizards (Reilly et al. 2022) that might be worth reviewing and citing in the appropriate section. That said, I think the main event here is the plea for habitat conservation in the region and small details like island age arguments are not critical to those key points.

Jim McGuire (signed review)

Reviewer: 3

Comments to the Author

Dear Editor and Author,

I am really excited to read this paper expecting that this paper might serve as important reference for biodiversity and environmental studies in Wallacea region. Also, the paper might provide insights for sustainable development in the region from the perspective of conservation.

Having read thoroughly, I think this paper is already strong and well-written in its current version. Nonetheless, several suggestions below might help to improve the clarity of the paper, and also from the perspective of readers that follow the factual issues in Wallaceae region, some issues might need to be highlighted as our concern now and in the near future.

Herewith the list of suggestions to resolve:

1. Figure 1, there seems inconsistency between the numbering of geological zone presented in Figure 1b and Supplementary Table 1 in particular for Zone C and Zone D. Zone C in Figure 1b might refer to Eastern Sulawesi (yet it is written as Southeast Sulawesi in Supp. Table 1) and vice versa. Please check again.
2. Figure 2, the parameter of percentage of forest cover might not be perfectly suited for geological zones that historically did not have extensive forest cover such as in Lesser Sunda region (e.g. Sumba, central Flores, Komodo islands, Timor) which contains a large proportion of native non-forest ecosystem types (e.g. dry land forest and savannah). No wonder if this region has comparatively low percentage of forest cover. Yet, the non-forest ecosystem type in this region is unique in term of biodiversity instead of being treated as proxy for threat (in a negative perspective).
3. Page 7, Lines 43-48: the sentence explaining the highly diverse coral seem a bit out of place in the context of paragraph that explain evolution and speciation. It might be more aligned if it is put in the previous paragraph when elaborating the

importance of Wallacea in term of biodiversity.

4. Page 9, Lines 3-6: the sentence explaining invasive fish species is also out of place since the context of the paragraph is explaining the historical threats. To my knowledge such fishes were just recently introduced compared to for example pigs and buffalo. I note later on, there is a section elaborating contemporary threat, which I think such sentence might be more suitable to put there.

5. Contemporary human pressures: There is an imminent threat from mining especially nickel and rare earth minerals. Indonesia has pledged to be the leader of nickel-based battery production for electronic vehicle. The country has the largest deposit of nickel, and most of it is located in Sulawesi (primarily in central and eastern parts) and islands in Molucca Sea (Halmahera, Obi, Gebe and Seram). I would expect a more extensive elaboration in this issue (I noted that there is a sentence mentioning this issue in Page 9, Lines 50-55 but it sounds downplayed since it is merged with the threat from oil palm plantation).

6. As per comment above, in the sections of Wallacea at a crossroad and Future directions, not much elaboration regarding the mining issues and how to resolve this problem (not as long as elaboration on ecosystem restoration concession in which in the context of Sulawesi and Wallacea region, no ER concession existed there). I would expect a deeper insight on how we work with rich mineral resources in Wallacea (especially in Sulawesi) sustainably in term of biodiversity (e.g., avoidance of high importance biodiversity area, low impact mining, setting aside HCVF, biodiversity offsetting, mine-site reclamation); and what are the future research directions regarding this issue studies in (e.g. restoration studies in ultramafic rocks such as in Sulawesi is rarely studied).

7. Figure 5c: the numbering "(c)" and "(f)" is missing from the caption. Please check again.

Reviewer: 1

Are all figures and tables clear and necessary: yes

Reviewer: 2

Are all figures and tables clear and necessary: Yes

Reviewer: 3

Are all figures and tables clear and necessary: Some need clarification as detailed in the attached file.

## Authors' Response



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16th August 2022

Dear Dr Collins and *Bioscience* editorial team,

Thank you for the invitation to submit a revised version of our manuscript "*Safeguarding imperiled biodiversity and evolutionary processes in the Wallacea center of endemism*" as a possible Forum article for *Bioscience*. We are delighted that the three reviewers shared our enthusiasm for the Wallacea region and emphasized the broad interest and need for the review.

We have taken on board the suggestions and comments and herewith provide a revised and updated version. We include additional material on invasive species, seasonality in the Lesser Sunda islands and the impacts of mining amongst other suggestions from the [reviewers](#), and have corrected the minor corrections they identified. We have reworked our figure on livelihoods and commodities (now figure 4) to include newly acquired data on [mining](#), and have added a new box and figure (now figure 5) to outline key concepts behind the uniqueness and fragility of seasonal forests in Wallacea. For all additional material included we have adhered to our original commitment to balance coverage of Indonesian-led publications as well other papers in the peer-review literature. We are confident that this expansion of material addresses all of the reviewer [feedback](#), [hmt](#) are happy to make any other changes deemed necessary.

In submitting this [manuscript](#) we confirm that the work enclosed has not been published or accepted for publication, and is not under consideration for publication elsewhere. This manuscript has been approved by all co-authors, and all individuals whose contributions warranted co-authorship have been recognized accordingly. We hereby declare that all authors named on this manuscript contributed material and have given prior consent to the formal submission of this version of the manuscript. We have added an author contribution statement as a separate file, and we have provided new versions of the figures to adhere to the resolution requirements of the journal.

On behalf of all co-authors, thank you in advance for considering our manuscript for publication in *Bioscience*.

Yours sincerely,

Dr Matthew Struebig and Ms Sabhrina Aninta  
Joint first authors

## SAFEGUARDING IMPERILED BIODIVERSITY AND EVOLUTIONARY PROCESSES IN THE WALLACEA CENTER OF ENDEMISM

Response to reviewers, August 2022

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### RESPONSE TO REVIEWER 1

#### **Comment 1:**

- This is an incredibly important subject, and I am very happy that the authors chose to address it. The difficulty in doing so is that the region has a very heterogeneous geological and evolutionary history. Different parts of Wallacea have very different floral and faunal communities, and even different

climatic and oceanographic conditions, thus each region will need a tailored conservation approach. - Very little attention is paid to why the marine fauna is so diverse compared to other tropical marine regions. For example, the Indonesian throughflow, or the consistent movement of water from the Pacific Ocean through Wallacea into the Indian Ocean, is a large reason why there are so many species present.

**Response 1:** *This is a valid point. We have now added a paragraph to the ‘natural laboratory’ section (now on page 8), which outlines why the marine fauna is so diverse:*

*“The region’s unstable tectonic environment continually creates diverse shallow habitats. During past sea level changes, these often remained connected to deep water, creating refuges that formed both a buffer from extinction as well as opportunities for divergent evolution of endemic species. The consistent movement of water and eddies created by the Indonesian throughflow ocean current increases the chance of subsequent larval dispersion at different rates across geological timescales (e.g. Linsley et al. 2010).”*

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**Comment 2:**

Page 5 line 2- “Wallacea archipelago” might be replaced by “archipelagos of Wallacea” as there are multiple distinct sets of islands within it.

**Response 2:** *Changed as suggested.*

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**Comment 3:**

Page 6 second line from bottom- should be Table S2 referring to the mammals, frogs, and plants.

**Response 3:** *Corrected – thanks for spotting the typo.*

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**Comment 4:**

Page 11- this line “Climate change also pushes terrestrial species outside of their thermal optima, changing phenology and seasonality that could drive transitions towards savanna (Siyum 2020), making tropical dry forest ecosystems of the Lesser Sunda islands (e.g. Sumba, Flores) particularly vulnerable.” Does not make sense to me. Many of the areas on these islands are already savanna, and the species that live there already have adapted to large seasonal variation in rainfall. Maybe explain.

**Response 4:** *Reviewers raised several queries regarding seasonal forests and the Lesser Sunda islands during their review, and so we have opted to include another box in the revision to elaborate on the multiple points. We have retained this sentence in the revision, but link to the new box. There we confirm the reviewer’s point that the Lesser Sundas lie within a climatic zone that supports dry forest and savanna, while each ecosystem comprises distinct ecological communities. However, we raise the problem that a switch from forest to savanna is potentially non-reversible because climate change brings increases frequency of fire and forest species are intolerant to these stressors.*

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**Comment 5:**

Page 11- this line “much of that movement on Wallacea’s rugged and convoluted islands is expected to be upslope” fails to mention that there is much less standing water on the steep slopes of the mountains there. Many streams only run after rains and there are few lakes or ponds available. This will greatly restrict the set of species that can move upslope and persist.

**Response 5:** *It is difficult to generalise this point across the whole of Wallacea, as Sulawesi in particular is renowned for its ancient lakes. The point raised is more relevant to the Lesser Sundas that tend to be drier and more seasonal than other parts of the region. However, we have added a sentence to elaborate on our point, as follows:*

*“While this high landscape complexity provides potential refuge areas that may help buffer some species against the most adverse impacts of climate change (Trew and Maclean 2020), the high numbers of species endemic to single islands or small island chains means that the potential for mountaintop extinctions is high should these refuges prove insufficient. This is particularly concerning for species with limited dispersal capabilities or those highly dependent on intact habitat or water resources on drier and more seasonal islands in the east.”*

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**Comment 6:**

Page 12-13- In many of the Lesser Sunda islands forest is not being cleared for agriculture, as the soil is too poor (e.g. Sumba, Sabu, Rote, Timor) and there is not enough water. Trees and any fallen wood are however collected as firewood and have huge effects on forest structure and the species present in the forest. This is my personal observation, but it might be discussed in the book “the ecology of nusa tenggara and maluku”

***Response 6:** We have now mentioned firewood collection and cultivation systems specifically in the new box on Wallacea’s forests.*

---

**Comment 7:**

- Introduced species deserve a bit more attention. Much of the insular fauna of Wallacea is not ecologically competitive compared to continental taxa that become introduced. Some introduced species presumably have a small effect on the ecosystem, others have a measurable large negative effect (Asian Toads, Reilly et al. 2017), and even others could potentially be having a large negative effect but we don’t know due to lack of data or complex ecological interactions (Asian Wolf Snakes, Reilly et al. 2019).

***Response 7:** This is a valid point, and thanks for the suggestions for case-studies to cite. The revision includes a minor restructuring of the ‘Contemporary pressures’ section to include a paragraph dedicated to invasive species – now page 10. Here, we elaborate on the problems posed by the Asian common toad, and also move material on freshwater invasives from elsewhere in the manuscript.*

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**Comment 8:**

- Figure 2 is misleading for small range species in Lesser Sundas. A number of new papers on reptiles, amphibians, and terrestrial invertebrates are showing that many species spanning multiple islands or island clusters represent both cryptic and non-cryptic species complexes, and that the true biodiversity of these groups is much greater than thought. This also means that the range sizes of each true species is much smaller than that of the species complex’s range.

***Response 8:** This is an equally valid point in other parts of the region, which we emphasize for Sulawesi in Figure 3. In the revised manuscript we have added this caveat to the Figure 2 legend as follows.*

*“Each plot shows the proportion of terrestrial vertebrate species that are range-restricted according to <https://www.iucnredlist.org/>. The assessment is limited to those taxa formally recognized as species and so may underrepresent endemism within species complexes, particularly in parts of Sulawesi (figure 3) and along the island chains of Nusa Tenggara.”*

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**Comment 9:**

Supp Table 1- ‘Mobilism of Sunda taxa onto Sumba block 60 Mya’ is not really correct. The plate fragment broke off then but was submerged for tens of millions of years before re-emerging and staying continuously emergent around 3-4 Ma (Fortuin et al. 1997). This later emergence is the geological information that is relevant for its role in the accumulation of biodiversity, even regarding most shallow water marine species as it has rapidly risen from many kilometers deep.

Supp Table 1- 'mobilism of Sahul taxa following Timor-Banda collision 2.4 Mya' - Some recent studies are suggesting an older time of collision into Sahul Shelf of around 4 Ma (Nguyen et al. 2013).

Supp Table 1- 'Rifting of Australian continental margin ~100 Mya' – see above comment. This is not really correct or relevant. The continent-arc collision that created these islands began around 4-5 Ma, and for Babar and some of the smaller islands ages of 1-2 Ma are likely (Kaneko et al. 2007). These are the geological events of biotic significance.

***Response 9:** We have now updated Supp Table 1 to include this information. Thanks for clarifying the current thinking of what is a very complicated topic.*

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**Comment 10:**

Supp Table 2- There are many more papers than this. A comprehensive list is of course too large for this type of paper, but perhaps more than one example per taxonomic group is warranted.

***Response 10:** We have updated Supp Table 2, adding more examples as advised. We also updated the legend to emphasize that these are examples of a more comprehensive list in the literature.*

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**RESPONSE TO REVIEWER 2**

**Comment 11:**

This manuscript could be considered a plea to the Indonesian government to utilize best conservation practices to protect the terrestrial and marine biodiversity of Wallacea, an imperiled tropical zone in Indonesia that supports exceptionally high levels of endemism as well as the complex evolutionary processes that led Alfred Wallace to establish the field of biogeography based on his studies in the region. This review is the end product of a workshop held by a large consortium of experts focused on the conservation of this critically important region.

The manuscript has several sections. The initial sections attempt to outline why Wallacea is interesting from the standpoint of its biogeography, evolutionary processes, and conservation. I think they did a decent job on the biogeography/evolutionary process front but it is difficult to be comprehensive in a few double-spaced pages so its best to think of their examples as vignettes. It might be worth their adjusting the text a bit to indicate that examples from the literature are referenced as a means of illustrating the types of interesting processes and systems that occur in Wallacea. For example, the discussion of the areas of endemism of Sulawesi showcases some of the notable examples from focal studies but certainly doesn't capture all that we know about species boundaries on this island. That's ok if presented as a series of vignettes rather than a comprehensive statement about diversification on this super complicated island.

***Response 11:** we have edited the text to emphasize that only a subset of the literature is reported, and the examples we provide are there to illustrate our points. The revised manuscript now includes more use of "For instance" or "For example" to make this clearer.*

---

**Comment 12:**

The sections that followed were more focused on anthropogenic impacts and recommendations for protection and restoration of damaged ecosystems. This is not my research area, but I have the sense that these sections were more comprehensive and really focused on cutting-edge suggestions for moving forward. I learned a lot in reading these sections. The Box on mangrove restoration, for example, was very interesting and new to me.

I think the authors have a compelling argument to make. The author line includes folks with prominent connections to higher branches of government who can use this document as a tool to enact change.

The higher profile the venue of publication, the more likely they are to gain traction with their arguments. As such, I would love to see this piece appear in BioScience and be taken seriously by leaders in the Indonesian government.

***Response 12:** Thanks for this positive feedback. We have added a second box on seasonal forests in our revision which we hope also generates similar interest.*

---

**Comment 13:**

I've added some comments directly on the MS where I think the text is misleading or where there might be factual errors. For example, one of my papers is cited as an example as "McGuire and Brown (2007)" when the paper actually has several other authors. I'll also point out – since I'm signing my review – that there are better discussions of the age of Lesser Sunda islands in papers published in the last few years on Limnonectes fanged frogs (Reilly et al. 2019) and Draco flying lizards (Reilly et al. 2022) that might be worth reviewing and citing in the appropriate section. That said, I think the main event here is the plea for habitat conservation in the region and small details like island age arguments are not critical to those key points.

***Response 13:** We apologise for the mistake in citation. One of our coauthors also pointed this out belatedly after we had submitted the manuscript. This was actually an error on the BioOne website consulted for the citation information, but we should have double checked from the downloaded pdf. It is now corrected*

*We have also incorporated some of the additional literature into the revision, although we have avoided discussion of the ages of the Lesser Sundas specifically in this version.*

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**Comment 14:**

[copied from the annotated pdf]  
Page 5, Line 11 "Lesser Sundas"

***Response 14:** Corrected.*

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**Comment 15:**

Page 6, Line 18-30, This is misleading as written. I think it would be more appropriate to say that Sulawesi originally formed as a series of smaller islands that only amalgamated into its current form about 1 million years ago. As written, suggests Sulawesi is not at least 23 million years old, which it is..

***Response 15:** Point taken. We have now revised this statement as follows:*

*"While most of the small islands in the southeast, as well as Timor and Seram, emerged around 5 million years ago (Mya), Sulawesi originally formed as a series of smaller islands that only amalgamated into its current form around 1 Mya (Vaillant et al. 2011, Hall 2013). This merger created distinct volcanic ridges, mountains and ancient lakes that characterize the island today. Although the formation of Sulawesi as a single island is relatively recent, deep ocean trenches to the east and west have separated it, as well as the wider Wallacea region, from the Sunda and Sahul continental shelves throughout the past 23 million years (Hall 2013)."*

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**Comment 16:**

Page 7, Line 25-27, Isn't this just the lack of study rather than an absence of differentiation. Citations needed..

***Response 16:** We have removed this statement in the revision.*

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**Comment 17:**

Page 8, Line 28-29, Don't the cave paintings indicate that 40,000 years is the minimum?

**Response 17:** *We have edited the sentence to imply that 40,000 ya is the minimum.*

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**Comment 18:**

Page 9, Line 3 ""More recent introductions.."

**Response 18:** *Corrected.*

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**RESPONSE TO REVIEWER 3**

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**Comment 19:**

I am really excited to read this paper expecting that this paper might serve as important reference for biodiversity and environmental studies in Wallacea region. Also, the paper might provide insights for sustainable development in the region from the perspective of conservation.

Having read thoroughly, I think this paper is already strong and well-written in its current version.

Nonetheless, several suggestions below might help to improve the clarity of the paper, and also from the perspective of readers that follow the factual issues in Wallaceae region, some issues might need to be highlighted as our concern now and in the near future.

Herewith the list of suggestions to resolve:

1. Figure 1, there seems inconsistency between the numbering of geological zone presented in Figure 1b and Supplementary Table 1 in particular for Zone C and Zone D. Zone C in Figure 1b might refer to Eastern Sulawesi (yet it is written as Southeast Sulawesi in Supp. Table 1) and vice versa. Please check again.

**Response 19:** *Thanks for spotting this. We have now corrected the labelling in Figure 1 so that the zones match up between the 3 visual items.*

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**Comment 20:**

2. Figure 2, the parameter of percentage of forest cover might not be perfectly suited for geological zones that historically did not have extensive forest cover such as in Lesser Sunda region (e.g. Sumba, central Flores, Komodo islands, Timor) which contains a large proportion of native non-forest ecosystem types (e.g. dry land forest and savannah). No wonder if this region has comparatively low percentage of forest cover. Yet, the non-forest ecosystem type in this region is unique in term of biodiversity instead of being treated as proxy for threat (in a negative perspective).

**Response 20:** *As stated in our response to other reviewers the peer-review process raised several queries regarding seasonal forests and the Lesser Sunda islands. We have therefore opted to include another box in the revision to elaborate on the multiple points. Here, we make the point that the Lesser Sunda region is much drier and has conditions for seasonal forest and savannah. We also add the caveat to Figure 1 that mapping and quantifying the extend of dry forests in this region is problematic:*

*Legend for Figure 1:*

*"Note also that forests are difficult to map consistently in the drier parts of Wallacea, notably the Lesser Sunda islands (Nusa Tenggara) – Box 1."*

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**Comment 21:**

3. Page 7, Lines 43-48: the sentence explaining the highly diverse coral seem a bit out of place in the context of paragraph that explain evolution and speciation. It might be more aligned if it is put in the previous paragraph when elaborating the importance of Wallacea in term of biodiversity.



**Response 21:** *We have now moved this sentence to a paragraph dedicated to the hyperdiversity in the marine realm (page 8) to address a query by Reviewer 1 (Response 1).*

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**Comment 22:**

4. Page 9, Lines 3-6: the sentence explaining invasive fish species is also out of place since the context of the paragraph is explaining the historical threats. To my knowledge such fishes were just recently introduced compared to for example pigs and buffalo. I note later on, there is a section elaborating contemporary threat, which I think such sentence might be more suitable to put there.

**Response 22:** *Good point. Since Reviewer 1 recommended more material on invasives, we have now elaborated on this topic with some examples from Sulawesi and moved this into the 'Contemporary pressures' section, as suggested.*

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**Comment 23:**

5. Contemporary human pressures: There is an imminent threat from mining especially nickel and rare earth minerals. Indonesia has pledged to be the leader of nickel-based battery production for electronic vehicle. The country has the largest deposit of nickel, and most of it is located in Sulawesi (primarily in central and eastern parts) and islands in Molucca Sea (Halmahera, Obi, Gebe and Seram). I would expect a more extensive elaboration in this issue (I noted that there is a sentence mentioning this issue in Page 9, Lines 50-55 but it sounds downplayed since it is merged with the threat from oil palm plantation).

**Response 23:** *Indeed, some of us are working on this very issue and agree it is a major threat. As mining is a highly politicized issue in Indonesia, we sought to avoid drawing attention to specific commodities without providing key evidence – which is mostly lacking. However, we have since obtained mining licensing data, which illustrates the huge expansion of mining very well. We have opted to include this as an additional pane to Figure 4. The findings contrast with the oil palm industry for example, as Wallacea provides only a miniscule proportion of the sector in Indonesia.*

*We have expanded on the expansion of mining in the 'Contemporary threats' section on page 10: "A deforestation surge over the last ten years, primarily in Central Sulawesi and northern Maluku, has been linked to the expansion of mining and industrial oil palm plantations (Supriatna et al. 2020). While the region's oil palm industry is at an early stage, mineral extraction has rapidly expanded since 2010 following a new mining governance regime in Indonesia. This led to more than 95% of the country's nickel coming from Wallacean islands (mainly Sulawesi and Halmahera), and around half of its gold (figure 4)."*

*Also on page 12:*

*"Hydroelectric dams and mining pose huge threats to the integrity and functioning of freshwaters, culminating in Sulawesi ancient lakes (von Rintelen et al. 2012). A gold rush in North Sulawesi, for example, led to elevated mercury concentrations in nearby rivers and high bioaccumulation in fish (Limbong et al. 2003)."*

*We also refer specifically to the mining industry in the context of alleviating poverty on page 18 in the 'Conclusions and future research' section – see next comment (#24):*

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**Comment 24:**

6. As per comment above, in the sections of Wallacea at a crossroad and Future directions, not much elaboration regarding the mining issues and how to resolve this problem (not as long as elaboration on ecosystem restoration concession in which in the context of Sulawesi and Wallacea region, no ER concession existed there). I would expect a deeper insight on how we work with rich mineral resources in Wallacea (especially in Sulawesi) sustainably in term of biodiversity (e.g., avoidance of high importance biodiversity area, low impact mining, setting aside HCVF, biodiversity offsetting, mine-site reclamation); and what are the future research directions regarding this issue studies in (e.g. restoration studies in ultramafic rocks such as in Sulawesi is rarely studied).

**Response 24:**

*We have added the following text to the end of the Discussion (page 18) to provide further insights to dealing with the effects of mining. To elaborate on all the Reviewer's suggestions would require a lot of additional text. Therefore, we have focussed on the overarching issue of where efforts are best targeted, and the need for improved monitoring, evaluation and information sharing.*

*There is huge scope for Indonesia's mining boom to follow the same trajectory if environmental and social safeguards are not adequately followed. While government requires all mining permit holders to follow good mining principles and plan for post-mining reclamation before they can begin operations, land reclamation is ecologically challenging and mostly oriented towards restoring soils and basic vegetation (Pratiwi et al. 2021). Minimizing the ecological footprint and engaging nearby communities in the first place (e.g. by optimizing land-use planning using the High Conservation Value approach, <https://www.hcvnetwork.org/>) is clearly a more cost effective strategy to minimize the impacts of mines and maximize the benefits they bring (Budiharta et al. 2018). Improved monitoring and evaluation of mining and post-mining operations are needed, to help identify best management practices that can be promoted broadly across the country. After all, Wallacea's central role producing the nickel needed to help the global transition to low carbon technologies should bring investments that benefit local communities, and not the land disputes and environmental damage reported from some sites (Hudayana et al. 2020).*

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**Comment 25:**

7. Figure 5c: the numbering "(c)" and "(f)" is missing from the caption. Please check again.

**Response 25:**

*Thanks for spotting this. We have corrected the caption (now Figure 6, with the addition of a new figure).*

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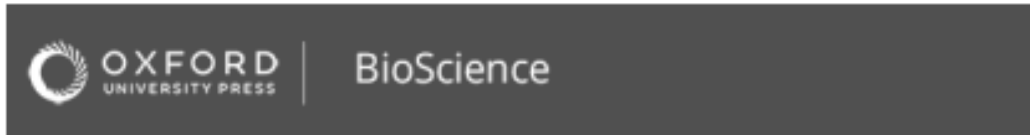
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**Safeguarding imperiled biodiversity and evolutionary processes in the Wallacea center of endemism**

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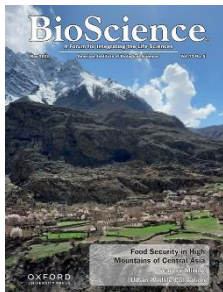
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