nature portfolio

Peer Review File

Optimizing biodiversity resilience: A wildlife dispersal-based framework for strategic conservation corridor design in protected area networks

Corresponding Author: Professor Yongfei Bai

This file contains all editorial decision letters in order by version, followed by all author rebuttals in order by version.

Version 0:

Decision Letter:

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Dear Professor Bai,

First of all, please allow me to apologise for the delay in sending a decision on your manuscript titled "Optimizing biodiversity resilience: A novel wildlife migration-based framework for strategic conservation corridor design in protected area networks". It has now been seen by 3 reviewers, and we include their comments at the end of this message. They find your work of interest, but some important points are raised. We are interested in the possibility of publishing your study in Communications Earth & Environment, but would like to consider your responses to these concerns and assess a revised manuscript before we make a final decision on publication.

We therefore invite you to revise and resubmit your manuscript, along with a point-by-point response that takes into account the points raised. Specifically, please ensure your methodology is described at a level of detail that will allow independent researchers to replicate your results, and please clearly define all the terms used to aid accessibility of your article. Please highlight all changes in the manuscript text file.

Please submit your point-by-point responses as a separate file, distinct from your cover letter where you can add responses to the Editors' comments that you do not want to be made available to the reviewers. Word files are preferred. We recommend that any figures, tables or graphs that are included in the response to reviewers are also included in the main article or Supplementary Information.

We are committed to providing a fair and constructive peer-review process. Please don't hesitate to contact us if you wish to discuss the revision in more detail.

Please use the following link to submit your revised manuscript, point-by-point response to the referees' comments (which should be in a separate document to any cover letter), a tracked-changes version of the manuscript (as a PDF file) and the completed checklist:
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We hope to receive your revised paper within six weeks; please let us know if you aren't able to submit it within this time so that we can discuss how best to proceed. If we don't hear from you, and the revision process takes significantly longer, we may close your file. In this event, we will still be happy to reconsider your paper at a later date, as long as nothing similar has been accepted for publication at Communications Earth & Environment or published elsewhere in the meantime.

Please do not hesitate to contact us if you have any questions or would like to discuss these revisions further. We look forward to seeing the revised manuscript and thank you for the opportunity to review your work.

Best regards,

Heike Langenberg, PhD
Chief Editor
Communications Earth & Environment

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We ask that you ensure your manuscript complies with our editorial policies. Please ensure that the following formatting requirements are met, and any checklist relevant to your research is completed and uploaded as a Related Manuscript file type with the revised article.

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In particular, the Data availability statement should include:
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- If applicable, a statement regarding data available with restrictions
- If a dataset has a Digital Object Identifier (DOI) as its unique identifier, we strongly encourage including this in the Reference list and citing the dataset in the Data Availability Statement.

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REVIEWER COMMENTS:

Reviewer #1 (Remarks to the Author):

The manuscript “Optimizing biodiversity resilience: A novel wildlife migration-based framework for strategic conservation corridor design in protected areas networks”, is an interesting study on Protected Areas (PAs) efficiency and connectivity in

China. I found it very interesting, especially the part of assessing the vulnerability of to forecast their capacity for protecting biodiversity and delivering ecosystem services. However, there are areas where clarification and structural improvements could significantly enhance the manuscript.
Firstly, the distinction between the creation or expansion of PAs and the creation of connectivity corridors is unclear. Or is connectivity just an added characteristic that should be included when defining PAs? It seems that the expansion proposed includes both PAs and corridors, but this dual focus should be explicitly outlined. A clear justification for integrating these two objectives is needed, especially given the differences in legal protections and policy frameworks that typically apply to PAs and corridors.
Secondly, the methods section lacks structure and detail. For instance, it is not clear how the “Identification of connectivity corridors” integrates with the “Identification of nature conservation networks of the future” shown in Figure 2. Providing a more thorough explanation of these processes would improve the manuscript’s rigor.
The discussion section omits several critical points, which I have detailed in the following section of line-by-line comments. Addressing these omissions could add depth and context to your findings.

Line-by-line comments:

Introduction:
Lines 61–62: If you describe corridors as “integrated consideration of functional connectivity, biodiversity values, and human well-being,” maybe you are prioritizing only corridors, what would be the definition of PAs? Clarifying this would help align the objectives with the methods.
Lines 75–77: Discuss what conservation means in the potential buffer areas. Are these areas subject to the same legal or policy restrictions as core PAs?
Lines 84–87: This illustrates again confusion between PAs and corridors. Are the corridors intended to be part of PAs, or do they connect separate PAs? Please clarify the ecological and legal distinctions.
Line 88: Specify which mismatches you are referring to.
Lines 123–136: This paragraph is better suited for the discussion section. Instead, you should briefly introduce the research framework and objectives. For example, where and how will the CBC framework be tested? What outcomes are expected? Also, while the abstract (lines 33–34) mentions meeting the 30% area-based targets, this is not adequately addressed in the introduction or methods sections.
Methods:
Line 144: For these secondary national parks you mention, you could assess whether they overlap with the proposed 30% expansion or corridors or which is their expected vulnerability. These could be insightful if data is available.
Line 145: What criteria were used to exclude some PAs?
Line 164: Is the maximum dispersal distance species-specific? If so, how was it determined?
Figure 2: Be cautious with the color scheme, as the two shades of blue are difficult to distinguish.
Line 184: Where did the data on existing corridors come from?
Line 204: Explain how you considered low-cost, high-biodiversity-value priorities. Are these explicitly factored into the templates used for PA identification? As far as it is explained I don’t think you are considering these two aspects in your PAs identification.
Lines 258–259: Revise this sentence for clarity.
Results:
Line 269: Clarify whether the two scenarios were overlapped.
Line 276: Figure 3a compares corridors with CZP, but is this equivalent to biodiversity importance? This needs a clearer explanation.
Lines 287–289: How did you differentiate between PAs and priority corridors?
Figure 4: Correct the typo in the figure labels: “Protected connected land.”
Last Section: Present the vulnerability map before discussing vulnerabilities in PAs for a more logical flow.
Discussion:
Line 334: Elaborate on this point to strengthen your argument.
Line 376: This finding (also stated in line 312) seems unexpected. Discuss potential explanations, such as overtourism inside PAs or buffer effects that reduce vulnerability. Consider how PA regulations might have contributed to these results.
Line 380: I suggest using "conservation opportunities" or "conservation implications" instead.

Reviewer #2 (Remarks to the Author):

Dear authors

I want to express my appreciation for the opportunity to read your study. You present a comprehensive analysis of the Chinese protected area system and thoughtfully explore how future conservation development should be guided. Your approach not only considers conservation representativeness within formal protected areas but also emphasizes the critical role of connectivity in sustaining biodiversity into the future. This dual focus demonstrates the ambition and scope of your work, and I commend the effort and depth of analysis that you have undertaken.
That said, I believe there are aspects of the manuscript that would benefit from further clarification. In particular, some elements of the methodological description and the rationale behind certain decisions remain unclear. This lack of clarity not only hinders a complete understanding of your study but also poses challenges for its replication. Addressing these issues would strengthen your contribution significantly and enhance its value to the field.
I have outlined below several points that I hope will serve as constructive feedback to help you refine and elevate your work

further. These suggestions are shared in the spirit of supporting the full realization of your study's potential and ensuring its lasting impact.
Thank you for your dedication to this important topic, and I look forward to seeing how your study continues to evolve.
Best regards,
The reviewer

ISSUES TO CONSIDER
1) In title and in parts of the manuscript the term migration is used. I guess that dispersal would be a better term to define it, as migration concerns seasonal movements within a generation of individuals. Dispersal best accommodated populational responses to environmental dynamics.
2) The abstract lacks a sentence where the main add ins of the study are clarified and expressed. It only refers to a novel conservation framework, without clarifying where novelty takes part.
3) First sentence of the introduction (LINE 51), consider to replace “necessitated” by “triggered”.
4) In the second paragraph of introduction (LINE 71) there is a mention the principle of conservation priorities. I would say that conservation priorities do not state a principle but rather a purpose or goal. Consider to rephrase to “Addressing this challenge, especially in the light of the unfulfilled Aichi Target 11, highlights the pressing need to establish and address spatial conservation priorities”.
5) LINES 75-77. This sentence is unclear. For example,e what resilient buffer mean? If you intend to refer to combine biodiversity representativeness with connectivity, consider to be more explicit.
6) LINES 122-123. Here you refer to novel framework and innovative approach, however I cannot figure out from the text where the novelty is. There are several examples of studies examining protected area representativeness and connectivity using a different protocol from the one here exposed, but I do not see which is the added value of the study proposed. You need to better clarify it somewhere around here.
7) LINE 141. As far as I know China does not make public in WDPA database protected area boundaries since 2014. What information did you get from WDPA?
8) LINE 169, what do you mean by distribution ranges? Are you referring to movement capabilities of the areas where the species occur? If the last one I do not realize what is that need for, as the connectivity analysis uses as nodes only the protected areas and not species locations.
9) LINE 171. The relationship between mean, median and 90th percentile with Dmax scores used is not clear. Is 10Km the mean, 30km the median and 100km the 90th percentile?
10) LINES 173-180. The values here reported seem a little bit arbitrary and they real condition the results obtained. There is a lack of references in the statements where you justify the use of the values. For example, why Dmax = 30km is optimal for future PA expansion?
11) LINES 181-187. This section is particularly troublesome. It is not mentioned how corridors are traced from the resistance values used and therefore how the number of corridors in each region emerge. Still, what PC index and ProtConn inform on, and were them used in the study for whatever reason?
12) LINES 188-196. As far as I understand I guess that there is no control on habitat similarity r distinctiveness in the analysis. So, in theory you can really get solutions linking patches of same habitat type, although this might be probabilistic unreasonable.
13) LINE 199-206, It is not clear why global conservation frameworks are used here. It lacks an explanation for this! Also what Median_CPC, Mean_CPC and Max-CPC are? Are there reflecting the use of Dmax values? If so, in Dmax you refer to 90th percentile and not the max value. Need some clarification here.
14) LINE 208. Again why Mean-CPC was used over the others to express future candidate areas for selection?
15) LINE 224-225. What it means, Euclidean distance between two orthogonal PCA axes? How that express climate vulnerability?
16) LINE 230. When mentioned that the inverse of CV (1/CV = mean/stddev) was used as an indicator of vulnerability it means that the more vulnerable areas refer to those with low variance or standard deviation. Please refer to the rationale of that decision!
17) LINE 246, what suitability of climatic and topographic conditions refer to? Please, clarify!
18) LINES 249-262. All this paragraph is not particularly understandable for people that do not domain matching analysis. You may consider to simplify it, with less jargon.
19) LINE 318. In Fig S
20) FIGURE 1, in the II phase there is a reference to optimization, but as far as I got, there is no formal optimization procedure used in the approach.
21) In supplementary material, FIGURE S1 lacks a legend.

Reviewer #3 (Remarks to the Author):

I appreciate the approach in general, with caveats. This work highlights the need for greater PA connectivity and a method for identifying where connectivity should be prioritized. There are a number of issues that do need to be addressed. It also suffers from a lack of proofreading.

The paper uses a confusing array of similar terms, that are often not defined in the paper:
• Conservation priority corridors (60)
• Conservation priority areas (73)
• Critical global connectivity areas (87)

• Biodiversity hotspots (88)
• Conservation priority zones (94)
• Critical connectivity corridors (106)
• Connectivity-based priority conservation areas (125)
Line 97 performance of PAs need to be defined – what kind of performance criteria. Management effectiveness, conservation outcome effectiveness, climate stability effectiveness, greenhouse gas mitigation? How can the performance of candidate PA performance be measured?
97-121 I struggle to see why this section on evaluating PA performance is included?
114-115 from PA performance to PA vulnerability – not the same thing
176 "These corridos are critical for balancing human activity and economic development with minimal environmental impact" – I don't think this sentence makes sense and needs to be restated.
189 what is meant by "overall efficiency of biodiversity conservation" – this needs to be defined
199-201 I recognize that the method of overlaying different conservation prioritizations is already published by Yang et al, but I fundamentally disagree with this method given the extremely different resolutions at which those prioritizations were done – e.g., G200 Ecoregions vs. KBAs. I suppose this comment is simply a personal editorial. I personally think that a better approach would be to use only the fine-scale prioritizations (e.g., KBAs) as part of a systematic conservation planning approach (sensu Margules & Pressey), incorporating a relatively fine-scale national habitat representation layer, to identify the biodiversity priorities, so that habitat representation would drive the prioritization.
204 "…that combined low cost, high connectivity, and high biodiversity value." But the three scenarios, as far as I can tell, represent three different levels of connectivity (based on three different Dmax dispersal distances), each with its' own cost. So I don't see where the low cost comes in?
225 Climate vulnerability is a measure of how susceptible a system or resource is to the negative effects of climate change – but what you seem to be calculating in the preceding section is a measure of (recent) past climate change for six climate indicators – this is not climate vulnerability, which can only be derived considering particular systems or resources.
226-233 It is unclear what the vegetation stability/vegetation vulnerability is meant to represent. You have a separate measure of anthropogenic activity (a proxy for threats to natural ecosystems) and a measure of climate change. What is unique about the vegetation measure (vs. the other two measures)? The rationale for including this measure is missing. In addition, I am skeptical of whether what is being combined is a meaningful measure of future habitat vulnerability.
257-258 this sentence does not make sense?
279 how are you measuring biodiversity conservation value here?
310 "…established PAs effectively mitigated climate vulnerabilities…" How is this mitigation measured? I am skeptical.
330-331 "…imperative to prioritize well-connected, expansive habitat networks." "Representative" is missing from this list and is my biggest concern with this paper.
336-337 "…southwestern and southeastern China possess greater biodiversity value." What is this statement based on? Number of species? Number of endemic species? "Biodiversity value" must be defined here. One can argue that all ecoregions possess equal value based on the principle of representivity.
371-372 "Future PA expansion efforts should focus not only on current human pressures but also on the vulnerability to human activities." This sentence does not make sense to me. Is the word "future" missing before "human activities"?
375 This may be true, but I don't understand how the paper is showing that candidate PAs have greater climatic vulnerability than existing PAs.
385-389 there are repeated sentences in this section
John Morrison

Decision Letter:

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Dear Professor Bai,

Your manuscript titled "Optimizing biodiversity resilience: A wildlife dispersal-based framework for strategic conservation corridor design in protected area networks" has now been seen by our reviewers, whose comments appear below. In light of their advice we would be happy, in principle, to publish a revised version in Communications Earth & Environment provided you fully justify how candidate protected areas have been differentiated from priority conservation corridors and clarify whether or not systematic conservation planning has been used.

We therefore invite you to revise your paper one last time to address the remaining concerns of our reviewers. At the same time we ask that you edit your manuscript to comply with our format requirements and to maximise the accessibility and therefore the impact of your work.

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Please review our specific editorial comments and requests regarding your manuscript in the attached "Editorial Requests Table".

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Please outline your response to each request in the right hand column. Please upload the completed table with your manuscript files as a Related Manuscript file.

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We hope to hear from you within two weeks; please let us know if you need more time.

Best regards,

Alienor Lavergne, PhD
Senior Editor
ORCID: 0000-0002-4591-1217
Communications Earth & Environment

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

Thank you for your answers and your thoughtful review of the manuscript. I think that the other reviewers' comments and your improvements have enhanced the quality of the research. I think it is suitable for publication.

I would only make a small comment regarding figure 1: you add as a step systematic conservation planning, as you are not applying that approach, I would suggest removing it. Also, the caption of the figure is not appropriate, it is too long the explanation of each of the three components should be self-explained in the figure, and if not, in the text where the figure is cited. These can be applied as well to the caption of Fig. 4

Congratulations!

Reviewer #3 (Remarks to the Author):

The authors made a great effort to respond to the first round of comments, and this is very much appreciated. The effort to evaluate and illustrate representation of biomes and ecoregions is a significant improvement. The overall paper is improved.

Yet I still have questions about the process used to differentiate candidate PAs from corridors.The difference between a candidate PA and a corridor is very unclear to me. The paper talks about candidate PAs and corridors in several places (e.g., line 102 " …it is imperative to expanding PA networks and designing CPCs that…" and lines 319-320 "…When combined, future PA networks and CPCs exceeded the 50% coverage target…"), but I don't see how or where the candidate PAs were identified? Related to this question: the caption for Figure 1 (lines 706-707) references systematic conservation planning - but I don't see systematic conservation planning used in the Methods? (additionally, there is text saying: "However, this approach was not feasible in our study due to the challenges in integrating KBAs with our geographically widespread CCCs." – So I am confused whether systematic conservation planning (Sensu Margules & Pressey) was used or not). I would have expected that the use of systematic conservation planning would expand the PA network using representation targets, and then the CPCs would connect the resulting new network? It is quite possible that I am not understanding the paper and how the candidate PAs are being identified – I have read the paper several times – if I don't understand it then others may also struggle.

More minor comments:
Line 42 – I simply do not understand the concept of "representation deficiencies within candidate PAs". What does this mean? Candidate PAs are usually identified because there are representation deficiencies.

Line 114 – "effetneness"?

Lines 456-458 - It is easy to see why candidate PAs could have more anthropogenic change than existing PAs, but why would candidate PAs have more climate change than existing PAs? What is your proposed explanation for this? It is not intuitive – one would assume that climate change would be the same whether a PA has been designated or not.

Line 487 – I think the "performance" should be "perform"

Figure 4 – I am struggling to interpret the Habitat Representation bar chart. My understanding of the MTA metric is that it needs to be developed separately for each target representation level – i.e., the MTA score for existing PAs, e.g., would be different from a 30% target representation level than for a 50% target representation level. I don't see how you can combine the two different target representation levels into one bar chart?

Figure 5 – I do not see how to interpret the different colors – where is the legend to explain them? What does each point represent? How is representation deficiency calculated for a single point? I am left not understanding the key question: to what extent is each biome represented? I am struggling to interpret this diagram.

Point-by-Point Response

Reply to Reviewer #1

1. Comments: The manuscript "Optimizing biodiversity resilience: A novel wildlife migration-based framework for strategic conservation corridor design in protected areas networks", is an interesting study on Protected Areas (PAs) efficiency and connectivity in China. I found it very interesting, especially the part of assessing the vulnerability of to forecast their capacity for protecting biodiversity and delivering ecosystem services. However, there are areas where clarification and structural improvements could significantly enhance the manuscript.

Firstly, the distinction between the creation or expansion of PAs and the creation of connectivity corridors is unclear. Or is connectivity just an added characteristic that should be included when defining PAs? It seems that the expansion proposed includes both PAs and corridors, but this dual focus should be explicitly outlined. A clear justification for integrating these two objectives is needed, especially given the differences in legal protections and policy frameworks that typically apply to PAs and corridors.

Secondly, the methods section lacks structure and detail. For instance, it is not clear how the "Identification of connectivity corridors" integrates with the "Identification of nature conservation networks of the future" shown in Figure 2. Providing a more thorough explanation of these processes would improve the manuscript's rigor. The discussion section omits several critical points, which I have detailed in the following section of line-by-line comments. Addressing these omissions could add depth and context to your findings.

Reply: We sincerely appreciate your valuable feedback on our manuscript. To address your concern regarding the distinction between the creation or expansion of protected areas (PAs) and the establishment of connectivity corridors, we have revised the Abstract and Introduction sections to explicitly clarify these concepts. In the updated conceptual framework, the expansion of PAs refers to formally designated areas that receive strict legal protections under relevant policy frameworks. In contrast, conservation priority corridors (CPCs) are designed to maintain connectivity across landscapes but are managed with more flexible approaches. We have further clarified that our framework has two primary objectives: (1) constructing a future-oriented nature conservation network that integrates PAs and CPCs, and (2) assessing the risks to these networks posed by anthropogenic activities, climate change, and habitat representation shortfalls. In response to another reviewer's comments, we have replaced the term "climate vulnerability and anthropogenic vulnerability" with "climate and anthropogenic activity changes" to more accurately reflect the scope our analysis, as our calculations do not directly measure vulnerability. Additionally, we have removed the concept

of vegetation vulnerability and introduced habitat representation as a key evaluation criterion. We have also emphasized that CPCs function as independent ecological elements outside the formally designated PA network. Their primary role is to enhance connectivity between PAs while remaining distinct in terms of governance and management flexibility. By integrating PAs and CPCs into a unified framework, our approach aims to maintain habitat connectivity across landscapes, which is essential for mitigating the impacts of anthropogenic activities and climate change on biodiversity[1,2].

In response to your feedback regarding the lack of structure and detail in the Methods section, we have substantially revised this section to enhance clarity and accessibility. We have explicitly defined all key terms and provided a step-by-step explanation of our methodology. Specifically, connectivity and biodiversity corridors (CBCs) are identified by overlaying cost-effective connectivity corridors (CCCs) with conservation priority zones (CPZs). The CCCs are calculated using a graph-based connectivity model that minimizes resistance across different regions to determine the least-cost paths (LCPs) connecting adjacent PAs. This model incorporates both ecological and economic factors to ensure cost-efficiency. The CPZs, on the other hand, are derived from seven global biodiversity prioritization templates (BH, CE, CPD, EBA, G200, IFL, and KBA), with biodiversity importance assessed based on the number of overlapping templates[3]. By integrating CCCs with CPZs, we identify CBCs that prioritize areas with low cost, high connectivity, and significant biodiversity importance. These corridors are further classified into formal PAs and informal conservation priority corridors (CPCs) based on different scenarios or species' dispersal distance gradients, reflecting species' ecological needs. Formal PAs providing stable habitats for species requiring strict protection, while CPCs facilitate movement and adaptation for species with broader habitat requirements or migration needs. Together, these elements form an integrated nature conservation network, a network of PAs and CPCs, designed to support future landscape conservation planning. These revisions provide a more structured, detailed, and transparent explanation of our methods, ensuring that the approach is both accessible and replicable for readers.

In response to your comment regarding the alignment of "Identification of connectivity corridors" with the "Identification of nature conservation networks of the future" in Figure 2, we have revised the figure to improve its clarity and focus. Specifically, we removed unnecessary elements and adjusted the color scheme to ensure consistency and visual coherence. The updated figure now distinctly illustrates the spatial distribution patterns of the CCCs we identified and the proposed nature conservation network. This revision enhances the figure's alignment with the study's objectives, making it more intuitive and directly relevant to our research focus.

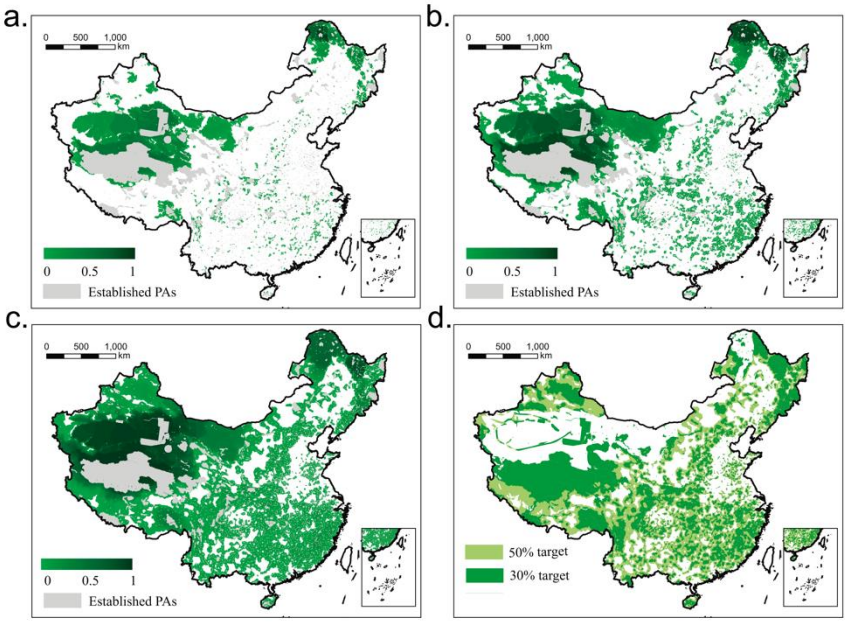

Figure 2 **Cost-effective connectivity corridors and nature conservation networks in China.** **a-c**) Existing protected area (PA) networks and cost-effective connectivity corridors (CCCs) based on 10 km, 30 km, and 100 km wildlife dispersal distances. The darkness of the green color in the corridor priority area map indicates the number of potential corridors. Values were normalized to a range of 0-1 to represent the corridor importance. **d**) The entire nature conservation networks in China. Dark green represents the 30% coverage target achieved by the current and candidate PAs. Light green represents the informally conservation priority corridors (CPCs). Together with the future PA network, they achieve the 50% coverage target.

1 Jantz, P., Goetz, S. & Laporte, N. Carbon stock corridors to mitigate climate change and promote biodiversity in the tropics. *Nat Clim Change* **4**, 138-142 (2014). https://doi.org/10.1038/nclimate2105

2 Feeley, K. J. & Rehm, E. M. Priorities for conservation corridors. *Nat Clim Change* **4**, 405-406 (2014). https://doi.org/10.1038/nclimate2207

3 Yang, R. *et al.* Cost-effective priorities for the expansion of global terrestrial protected areas: Setting post-2020 global and national targets. *Sci. Adv* **6**, eabc3436 (2020). https://doi.org/10.1126/sciadv.abc3436

2. Line-by-line comments: Introduction:

(1) Lines 61–62: If you describe corridors as “integrated consideration of functional connectivity, biodiversity values, and human well-being,” maybe you are prioritizing only

corridors, what would be the definition of PAs? Clarifying this would help align the objectives with the methods.

Reply: Thank you for your insightful comment. We have carefully revised the manuscript to explicitly clarify the distinction between protected areas (PAs) and conservation priority corridors (CPCs), ensuring their roles and definitions are clearly delineated. PAs are formally designated, legally established areas designed to secure core habitats and provide long-term protection under strict legal and policy frameworks. They primarily address the needs of species and ecosystems that rely on stable, localized habitats. In contrast, CPCs serve as informal extensions that enhance ecological connectivity by linking fragmented habitats and supporting species dispersal, migration, and adaptation across broader spatial scales. CPCs are particularly critical for addressing dynamic ecological processes, such as those driven by climate change, that cannot be fully accommodated within the fixed boundaries of PAs. The revised text explicitly highlights these distinctions by emphasizing the complementary roles of PAs and CPCs in creating a cohesive and adaptive conservation network. We hope this clarification aligns with your expectations and strengthens the coherence and scientific rigor of the manuscript.

"Expanding the boundaries of PAs is essential to safeguarding core habitats and ensuring long-term protection under strict legal and policy frameworks. While PAs are formally established to conserve these core habitats, conservation priority corridors (CPCs) play a complementary role by enhancing connectivity across fragmented landscapes, facilitating species movement, and linking isolated PAs. Unlike PAs, CPCs are not formally designated but serve as flexible, informal mechanisms that strengthen the overall functionality of the nature conservation networks. Both PA expansion and CPC designation require an integrated approach, considering factors such as functional connectivity, biodiversity importance, and cost-effectiveness. Together, these formal and informal protection strategies create a cohesive network that enhances biodiversity protection while balancing ecological, social, and economic priorities. This diversified approach ensures a more resilient and adaptive framework for nature conservation."

(2) Lines 75–77: Discuss what conservation means in the potential buffer areas. Are these areas subject to the same legal or policy restrictions as core PAs?

Reply: We have revised this section to provide a clearer distinction between PAs and priority areas in terms of their conservation goals, and legal or policy frameworks that govern them. The updated text emphasizes that PAs are formally designated area with legally binding protections aimed at conserving biodiversity and ecosystems. In contrast, priority areas are identified based on ecological significance but operate under more flexible management

approaches, often lacking formal legal mandates. Furthermore, the revised section underscores the complementary relationship between PAs and priority areas, illustrating how priority areas act as informal extensions to PAs. By enhancing ecological connectivity and improving species and habitat representation, priority areas contribute to broader conservation goals while accommodating adaptive and less restrictive management strategies. This integrated approach strengthens the overall effectiveness of conservation efforts by bridging gaps in formal protection frameworks.

"This approach, establishing and addressing spatial conservation priorities, aims to identify priority areas as flexible, informal pathways that balance biodiversity conservation with economic development, imposing fewer restrictions to human activities compared to formally protected areas. However, research on the integration of priority areas as complementary extensions to legally defined PAs remains limited. This gap highlights the urgent need for integrative approaches that reconcile competing land-use demands while optimizing biodiversity protection."

(3) Lines 84–87: This illustrates again confusion between PAs and corridors. Are the corridors intended to be part of PAs, or do they connect separate PAs? Please clarify the ecological and legal distinctions.

Reply: We apologize for the confusion between PAs and corridors in the original manuscript. In response to your feedback, as well as suggestions from other reviewers, we have restructured this section to provide a more focused and coherent discussion. The revised text no longer addresses PAs and corridors explicitly but instead offers a concise overview of systematic conservation planning[4]. This approach emphasizes the identification and protection of areas of high biodiversity importance, while simultaneously considering habitat representation and the trade-offs between societal costs and wildlife dispersal needs[5]. Despite its strengths, systematic conservation planning frequently neglects the critical element of connectivity[6], which is essential for maintaining ecological processes and species movement. This oversight can significantly undermine the effectiveness of PA networks in mitigating biodiversity loss[7], highlighting the need for more integrated and connectivity-aware conservation strategies.

"To this end, systematic conservation planning has emerged as an effective framework for designing PAs and priority areas with clearly defined, quantifiable targets aimed at safeguarding biodiversity. This approach seeks to identify and prioritize areas that meet conservation objectives while minimizing trade-offs between societal costs and wildlife dispersal needs. A key consideration in systematic conservation planning is its ability to effectively encompasses areas of high biodiversity important. Equally critical is ensuring

adequate habitat representation, which serves as a fundamental criterion for establishing biodiversity priorities. However, a recurring limitation in related research is the frequent oversight of connectivity, a vital component for maintaining ecological processes and species movement. This gap significantly hampers the effectiveness of existing PA networks in mitigating biodiversity loss."

4 Margules, C. R. & Pressey, R. L. Systematic conservation planning. *Nature* **405**, 243-253 (2000). https://doi.org/10.1038/35012251

5 De Alban, J. D. T. *et al.* Conservation beyond the existing protected area network is required to improve species and habitat representation in a global biodiversity hotspot. *Biol Conserv* **257**, 109105 (2021). https://doi.org/10.1016/j.biocon.2021.109105

6 Rodrigues, A. S. L. & Cazalis, V. The multifaceted challenge of evaluating protected area effectiveness. *Nat. Commun.* **11**, 5147 (2020). https://doi.org/10.1038/s41467-020-18989-2

7 Santangeli, A. *et al.* Mixed effects of a national protected area network on terrestrial and freshwater biodiversity. *Nat. Commun.* **14**, 5426 (2023). https://doi.org/10.1038/s41467-023-41073-4

(4) Line 88: Specify which mismatches you are referring to.

Reply: We have revised the sentence to clarify that the mismatches specifically refer to spatial discrepancies between critical global connectivity areas and key biodiversity areas (KBAs) within unprotected regions. Although these areas are both ecologically significant, their spatial distribution does not always overlap.

"Currently, two-thirds of critical global connectivity areas and key biodiversity areas (KBAs) remain unprotected, revealing significant spatial mismatches between these ecologically crucial zones."

(5) Lines 123–136: This paragraph is better suited for the discussion section. Instead, you should briefly introduce the research framework and objectives. For example, where and how will the CBC framework be tested? What outcomes are expected? Also, while the abstract (lines 33–34) mentions meeting the 30% area-based targets, this is not adequately addressed in the introduction or methods sections.

Reply: Great point! We have restructured the introduction to focus on the research framework and objectives. Specifically, we have clarified how the CBC framework was tested and its expected outcomes.

First, we introduce the Connectivity & Biodiversity Conservation (CBC) framework, a novel approach designed to optimize biodiversity conservation through systematic conservation planning. The CBC framework integrates graph-based connectivity analysis with biodiversity prioritization overlays to identify conservation priorities, explicitly addressing both ecological effectiveness and cost-efficiency. Second, this study applies the CBC framework aims to achieve two key outcomes: 1) identifying a future conservation network that formally protects 30% of China's national land as PAs and informally designates an additional 30% as CPCs; and 2) evaluating the impacts of climate change and anthropogenic activities on habitat representation shortfalls across China. Furthermore, we have elaborated on the 30% area-based targets, ensuring they are consistently addressed in the introduction and methods sections. These revisions aim to provide a clear, concise, and focused overview of the framework and its application. We believe these changes address your concerns and enhance the clarity and coherence of the manuscript.

"To address these multifaceted challenges, this study introduces the Connectivity & Biodiversity Conservation (CBC) framework, a systematic approach designed to optimize biodiversity conservation by integrating connectivity, biodiversity preservation, and cost-effectiveness. The CBC framework aims to enhance and expand PA network through a scientifically grounded and practical methodology. Applied across China, this framework seeks to achieve two key objectives. First, it identifies a future nature conservation network by formally designating 30% of the national land as PAs and informally designating an additional 30% as CPCs. This is accomplished through a graph-based connectivity analysis combined with biodiversity prioritization overlays, ensuring a balanced strategy that maximizes ecological effectiveness while maintaining cost-efficiency. Second, the framework assesses the risks posed by climate change and anthropogenic activities in relation to habitat representation shortfalls. By evaluating the spatial distribution and overlap patterns of these risks and deficiencies, the analysis enables the prioritization of future PAs. This integrative approach not only advances the scientific understanding of complex ecosystem dynamics but also provides actionable tools for policymakers and conservation practitioners. By bridging the gap between theoretical conservation biology and applied landscape management, the CBC framework offers a pathway toward more effective, resilient, and sustainable biodiversity protection in the face of global environmental change."

3. Comments: Methods:

(1) Line 144: For these secondary national parks you mention, you could assess whether they overlap with the proposed 30% expansion or corridors or which is their expected vulnerability. These could be insightful if data is available.

Reply: We fully agree with your suggestions and had previously considered conducting such an analysis. However, we were unable to proceed due to the lack of access to the necessary data required to evaluate the overlap between secondary national parks and the proposed 30% expansion or corridors.

(2) Line 145: What criteria were used to exclude some PAs?

Reply: The issue you highlighted is of significant importance and has helped us identify and rectify a potentially critical error. Specifically, the statement, "Many protected lands in China do not meet the International Union for Conservation of Nature (IUCN) criteria for nature reserves," requires revision and clarification. First, logically, this statement should precede the sentence, "Only national parks, nature reserves, and forest/wetland parks were classified as PAs," as it serves as the criterion used to exclude certain protected areas (PAs) from our analysis. Furthermore, we recognize a critical oversight in the original statement. At the time, we failed to consider that geological heritage, paleontological heritage, and scenic areas within China's PA system may align with IUCN Categories I, III, or V. Consequently, the claim that "Many protected lands in China do not meet the International Union for Conservation of Nature (IUCN) criteria for nature reserves" is both inaccurate and ultimately meaningless.

This oversight stems from the inherent differences between China's PA classification system and the IUCN framework. Upon reflection, we acknowledge that referencing the World Database on Protected Areas (WDPA) and IUCN standards in this context was inappropriate, as these frameworks are not fully applicable to the unique characteristics of China's PA system. To address this, we have revised the manuscript to focus exclusively on China's national classification system, ensuring the methodology is accurately represented and avoiding unnecessary confusion.

Therefore, we have deleted "*Many protected lands in China do not meet the International Union for Conservation of Nature (IUCN) criteria for nature reserves. These areas, often characterized by small size, overexploitation for tourism, and inadequate management, were excluded to avoid potential overestimation of connectivity.*" from the original paragraph.

(3) Line 164: Is the maximum dispersal distance species-specific? If so, how was it determined?

Reply: Thank you for your valuable comment. We recognize that dispersal distances vary significantly among species due to differences in ecological traits and behaviors. To address this variability, we adopted a coarse-filter approach by establishing predefined dispersal

distance gradients (e.g., 10 km, 30 km, and 100 km). These gradients are informed by existing literature[8,9] and are designed to encompass the movement abilities of a broad range of terrestrial species. This approach enables us to account for species with diverse dispersal capacities while ensuring the feasibility of large-scale connectivity analysis. To improve clarity and provide a more precise and coherent explanation of our methodology, we have revised these sentences and reorganized the "Identification of cost-effective connectivity corridors" section in the Methods.

"Dispersal distance play a critical role in determining the corridors that connect adjacent PA patches, enabling wildlife movement within a predefined range. However, defining dispersal distance is inherently challenging due to the variability in movement abilities across species. To address this, we adopted a coarse-filter approach by establishing dispersal distance gradients designed to encompass the movement abilities of a wide range of terrestrial species. Based on previous studies, we set typical dispersal distances at 10, 30, and 100 km thresholds that are known to cover the movement ranges of most terrestrial species. To ensure these gradients are applicability to China, we followed the methodology of Sun et al., focusing specifically on terrestrial mammals. Using a list of important habitats for protected terrestrial wildlife species in China, we identified 126 priority-protected mammals and estimated their movement abilities based on body weight, diet, and other ecological niche parameters through allometric relationships. By aggregating these dispersal distances, we calculated the median, mean, and 90th percentile of movement ability across regions. The results indicate that the calculated values closely align with the predefined dispersal thresholds of 10 km, 30 km, and 100 km, confirming the applicability of these thresholds for studies conducted in China."

8 Palfrey, R., Oldekop, J. A. & Holmes, G. Privately protected areas increase global protected area coverage and connectivity. *Nat. Ecol. Evol* **6**, 730-737 (2022). https://doi.org/10.1038/s41559-022-01715-0

9 Saura, S., Bastin, L., Battistella, L., Mandrici, A. & Dubois, G. Protected areas in the world's ecoregions: How well connected are they? *Ecol. Indic* **76**, 144-158 (2017). https://doi.org/10.1016/j.ecolind.2016.12.047

(4) Figure 2: Be cautious with the color scheme, as the two shades of blue are difficult to distinguish.

Reply: We have revised Figure 2 to improve clarity and interpretability by presenting the data in four separate maps. Panels (a) to (c) show the identified 10 km, 30 km, and 100 km cost-effective connectivity corridors (CCCs), alongside the distribution of existing protected areas. The darkness of the green color gradient represents the number of identified candidate

corridors, with the values normalized to a range of 0-1 to indicate the corridor importance. Panel (d) displays the solutions for achieving 30% and 50% conservation targets. Light green denotes the informally designated conservation priority corridors (CPCs). This redesigned figure aims to provide a more intuitive and detailed visualization of spatial patterns and conservation priorities, facilitating the interpretability of the results for readers.

(5) Line 184: Where did the data on existing corridors come from?

Reply: The overlapping patterns of model-generated cost-effective connectivity corridors (CCCs) were analyzed to quantify their relative importance. Areas exhibiting greater overlap among CCCs were identified as having higher connectivity value, as they represent regions with the greatest potential to enhance landscape connectivity effectively. To improve clarity and logical flow, we revised these sentences and reorganized the "Identification of cost-effective connectivity corridors" section of the Methods, ensuring a more coherent presentation of the analytical approach.

"To assess the priority of these connectivity corridors (referred as "corridor importance" hereafter, see Figure 2), we defined by the number of overlapping CCCs within a given area. Unlike linear pathways, CCCs span broader regions characterized by a cost gradient (like a spreading watershed). The spatial overlap of CCCs across their coverage areas underscores their significance in enhancing connectivity. Specifically, we delineated CCCs using least-cost path (LCP) analysis, which identifies corridors by minimizing cumulative resistance across the landscape. This approach enabled us to quantify corridor importance based on the spatial overlap and distribution of CCCs within each region, providing a robust framework for prioritizing connectivity conservation efforts."

(6) Line 204: Explain how you considered low-cost, high-biodiversity-value priorities. Are these explicitly factored into the templates used for PA identification? As far as it is explained I don't think you are considering these two aspects in your PAs identification.

Reply: We sincerely appreciate your valuable comment. Both low-cost and high-biodiversity-value priorities were integral to our identification of protected areas (PAs) and conservation priority corridors (CPCs). To address this, we have thoroughly revised the Methods section to provide greater clarity. Specifically, low-cost priorities are explicitly incorporated in the "Identification of cost-effective connectivity corridors" section, where we modeled connectivity resistance using human footprint data and slope. This approach allowed us to identify least-cost paths that account for both ecological and economic considerations. High-biodiversity-value priorities are addressed in the "Identification of connectivity & biodiversity corridors" section, where we overlaid seven global biodiversity prioritization

templates to delineate conservation priority zones (CPZs). Biodiversity importance within these zones was quantified based on the number of overlapping templates. We hope this revised explanation effectively clarifies how these two critical aspects were systematically integrated into the identification of protected areas and corridors.

For low-cost priorities

"Connectivity "resistance" was modeled using China's human footprint dataset, weighted by slope derived from a digital elevation model (DEM) to account for the combined impact of human activities and steep topography on mammal movement. This resistance surface was used to identify least-cost paths (LCPs) between adjacent PAs by minimizing cumulative resistance. The "cost" associated with LCPs encompasses two dimensions: ecological cost and economic cost. Ecological cost reflects the hypothetical resistance species encounter when moving between PAs, serving as a proxy of cost-effective connectivity corridors (CCCs) in maintaining landscape connectivity. Economic cost represents the resources required to conserve CCCs, which escalate in areas with higher human activity. By prioritizing CCCs based on these dual dimensions, we enhance connectivity while balancing ecological and economic considerations, ensuring a cost-effective approach to conservation planning."

For high-biodiversity-value priorities

"Connectivity & biodiversity corridors (CBCs) were derived by overlaying CCCs with conservation priority zones (CPZs). To identify CPZs, we employed the methodology of Yang et al., which involved spatially integrating seven global biodiversity prioritization templates (BH, CE, CPD, EBA, G200, IFL, and KBA) and extracting the CPZs specific to the China region. The biodiversity importance of each CPZ (referred to as "biodiversity importance" hereafter, see Figure 2) was quantified based on the number of overlapping templates, ranging from 1 to 7. By overlaying these CPZs with CCCs, we obtained CBCs that integrate low cost, high connectivity, and high biodiversity value, thereby optimizing conservation efforts across ecological and economic dimensions."

(7) Lines 258–259: Revise this sentence for clarity.

Reply: In response to your feedback and suggestions from other reviewers, we have reorganized this section to enhance clarity and readability. To achieve this, we removed excessive terminology and streamlined the detailed content of the matching analysis. Specifically, the material originally presented in lines 258–259 has been omitted from the revised version, ensuring a more concise and accessible presentation of the methods.

4. Comments: Results:

(1) Line 269: Clarify whether the two scenarios were overlapped.

Reply: Yes, there is significant overlap between the two scenarios, as illustrated in Figure 2. As dispersal distance increases, the spatial extent of both cost-effective connectivity corridors (CCCs) and connectivity & biodiversity corridors (CBCs) expands. Furthermore, in scenarios with higher dispersal distance gradients, the CCCs and CBCs identified under lower dispersal distance gradients are nested within those of the higher gradients. To enhance clarity, we have explicitly described this nested relationship in the revised manuscript, ensuring a more precise understanding of how dispersal distance influences the spatial configuration of these corridors.

"Three CBCs scenarios identified 1549, 3356, and 6389 corridors, respectively. These corridors collectively covered 7.6%, 20.0%, and 47.8% of China's terrestrial land surface. Notably, as dispersal distance increased, the spatial extent of the CBCs expanded, with corridors identified under smaller dispersal distance scenarios nested within those of larger dispersal distance scenarios."

(2) Line 276: Figure 3a compares corridors with CZP, but is this equivalent to biodiversity importance? This needs a clearer explanation.

Reply: We appreciate your insightful comments and have addressed them thoroughly during the revision process. To enhance clarity and eliminate ambiguity, we have explicitly defined key terms, ensuring consistency throughout the manuscript. Specifically, the term "biodiversity importance" is operationalized through the spatial integration of seven globally recognized biodiversity prioritization templates, which collectively provide a robust framework for assessing biodiversity value.

"To identify CPZs, we employed the methodology of Yang et al., which involved spatially integrating seven global biodiversity prioritization templates (BH, CE, CPD, EBA, G200, IFL, and KBA) and extracting the CPZs specific to the China region (Fig. S1). The biodiversity importance of each CPZ (referred to as "biodiversity importance" hereafter, see Fig. 2) was quantified based on the number of overlapping templates, ranging from 1 to 7."

(3) Lines 287–289: How did you differentiate between PAs and priority corridors?

Reply: We sincerely apologize for the lack of clarity in the original manuscript regarding the distinction between protected areas (PAs) and conservation priority corridors (CPCs, as defined in the revised manuscript). Specifically, the omission of explicit details about their

legal protections, policy frameworks, and the connectivity scenarios used to identify candidate PAs and CPCs likely led to confusion in the Results section. To address this, we have now incorporated clear distinctions and precise definitions in both the Introduction and Methods sections, as previously outlined in our response to your earlier concern. These revisions aim to provide a comprehensive understanding of the differences between PAs and CPCs, ensuring transparency in our methodology. Furthermore, we have made additional refinements to the Results section to explicitly address your concerns about how we differentiate between PAs and "priority corridors."

"The proposed networks significantly expand the spatial coverage of the currently effective PA networks, increasing it from 14.0 % to 34.0 %. Furthermore, they designate an additional 27.8 % of the landscape as informal CPCs pathways."

(4) Figure 4: Correct the typo in the figure labels: "Protected connected land."

Reply: In the revised manuscript, we have removed this figure and replaced it with stacked bar plots to better visualize the contributions of future nature conservation networks. This alternative approach effectively illustrates the interplay across three critical dimensions: coverage, connectivity, and habitat representation.

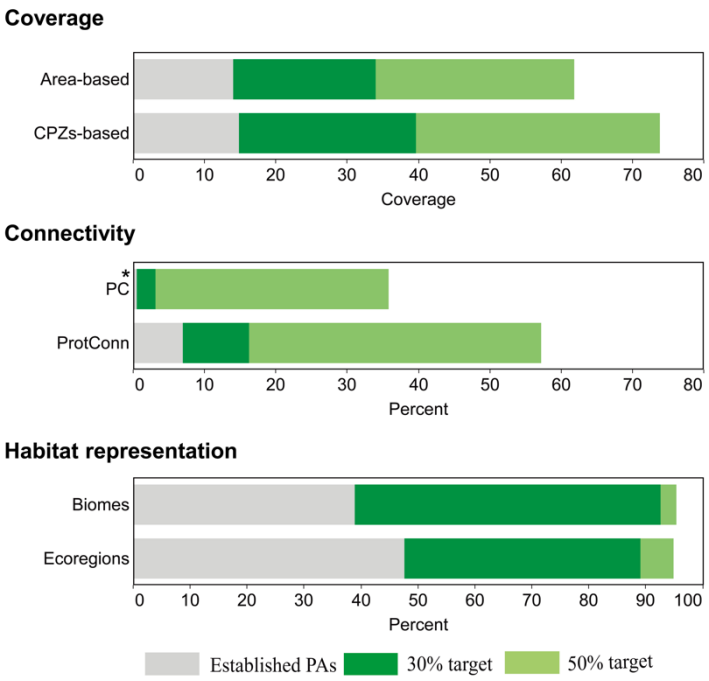

Figure 4 **Achievement of coverage, connectivity and habitat representation in multiple scenarios.** The achievement of coverage was measured using two metrics: coverage based on the national terrestrial land surface (area-based) and coverage based on conservation priority zones

(CPZs-based). The achievement of connectivity was quantified using two metrics: probability of connectivity (PC) and protected connected (ProtConn), which assess connectivity performance. The achievement of habitat representation was evaluated using mean target achievement (MTA), which measures based on biomes and ecoregions. Dark green represents the 30% coverage target achieved by the current and candidate protected areas (PAs). Light green represents the informally conservation priority corridors. Together with the future PA network, they achieve the 50% coverage target.

(5) Last Section: Present the vulnerability map before discussing vulnerabilities in PAs for a more logical flow.

Reply: We sincerely appreciate your constructive suggestion. In response, we have revised the logical flow of the final section of the Results to improve coherence and clarity. Specifically, we have reordered the presentation of Figure 5 and Figure 6 to align more effectively with the narrative progression.

5. Comments: Discussion:
(1) Line 334: Elaborate on this point to strengthen your argument.

Reply: We appreciate your valuable suggestions. We have now expanded our discussion regarding the observed discrepancies between corridor importance areas and biodiversity importance areas. Our revision specifically focuses on the contrasting ecological conditions between northwestern and southeastern/southwestern China, which present distinct conservation challenges. This regional comparison allows us to emphasize the varying priorities for connectivity conservation across different regions.

"There is a significant spatial mismatch between corridor importance areas and biodiversity importance areas, emphasizing the need for region-specific conservation strategies. In northwestern China, characterized by high altitudes and arid climates, intact habitats demonstrate high connectivity but relatively lower biodiversity importance, particularly in terms of species richness and endemism. This suggests that conservation efforts in this region should prioritize maintaining and preventing the degradation of existing corridors, which are crucial for sustaining ecological processes in these fragile ecosystems. In contrast, southeastern and southwestern China, with their warm climates, diverse habitats, and exceptional biodiversity significance in terms of high species richness and the presence of threatened species, face escalating pressures from land-use intensification and urbanization. Here, conservation strategies must focus on protecting biodiversity-rich areas while simultaneously enhancing corridor importance to improve ecosystem function and resilience."

(2) Line 376: This finding (also stated in line 312) seems unexpected. Discuss potential explanations, such as overtourism inside PAs or buffer effects that reduce vulnerability. Consider how PA regulations might have contributed to these results.

Reply: We sincerely appreciate your valuable feedback and share your concerns regarding the initial results. In response to suggestions from other reviewers, we have removed the "vegetation vulnerability" dimension from the manuscript. This indicator was initially included as a covariate in our matching analysis, where we used vegetation's initial conditions to match climate and anthropogenic activities. Upon removing vegetation-related variables, we observed changes in the matching results for anthropogenic activities, while the results for climate remained robust. Importantly, we ensured that the initial human footprint condition was consistently maintained throughout the matching analysis, thereby enhancing the reliability of the revised results.

The previously perplexing outcomes can now be attributed to the influence of the vegetation-related covariate. By eliminating this variable, the analysis shifted its focus to climate and topographic factors, which are more objective and directly linked to human activity. As other reviewers rightly pointed out, using GPP as a vegetation vulnerability indicator is problematic, as GPP often reflects the complex interplay between climate, biology, and human activity rather than serving as an independent, objective measure. This likely obscured the roles of climate, topography, and land cover in the matching process.

Consequently, the revised results, which exclude vegetation-related variables, align more closely with both the methodological framework and the interpretation of the outcomes. We deeply regret the lack of robustness in the earlier findings and are grateful for your critical feedback, which has significantly strengthened the manuscript. We have thoroughly addressed these issues in the revised version.

"Our findings further demonstrate that existing PAs are exposed to anthropogenic disturbances, driven by unpredictable fluctuations in human activity intensity over time. However, these disturbances are significantly lower in PAs compared to candidate PAs and unprotected areas, underscoring their effectiveness in mitigating human impacts. By analyzing the 2000–2018 human footprint dataset, our study provides a comprehensive assessment of conservation outcomes in the 21st century, highlighting the critical role of current PAs in managing anthropogenic pressures. These results not only emphasize the success of existing PAs in reducing disturbances but also underscore the urgent need to address anthropogenic impacts as a central challenge in conservation planning. As the global network of PAs expands, effectively managing these impacts will be essential to ensuring the long-term resilience and functionality of protected ecosystems."

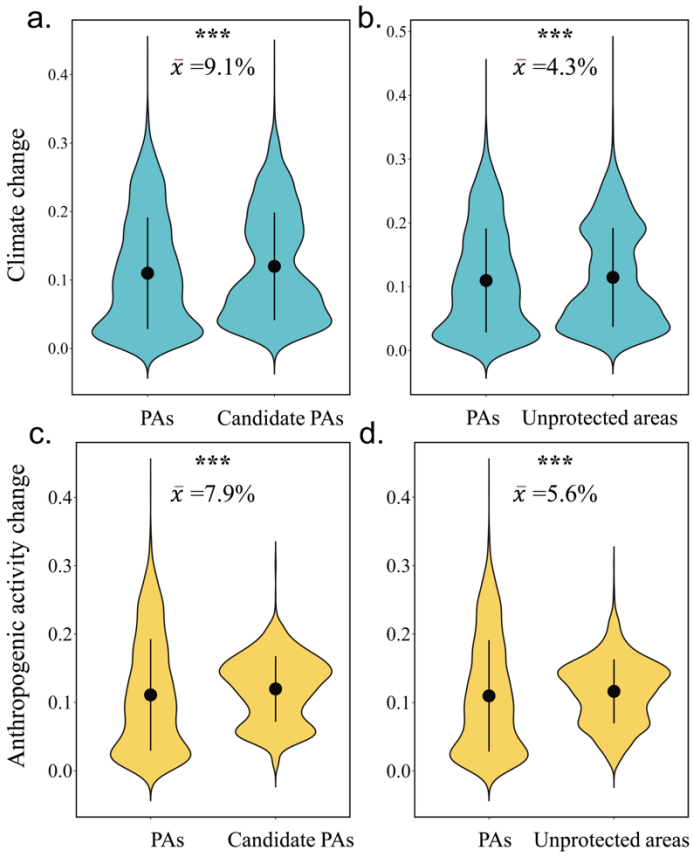

Figure 6 The spatial distribution of climate and anthropogenic activity changes. Violin plots showing (a) climate and (c) anthropogenic activity changes for matched established protected areas (PAs) and unprotected areas (excluding a 1-fold PA buffer), as well as (b) climate and (d) anthropogenic activity changes for matched established and candidate PAs. Points and lines show means and standard deviations, respectively. *P*-values were calculated using Mann-Whitney U tests. $\bar{x}$ represents the percent difference in mean changes.

(3) Line 380: I suggest using "conservation opportunities" or "conservation implications" instead.

Reply: Thanks a lot! We have revised the subsection title to “Conservation Implications”.

Reply to Reviewer #2

1. Comments: I want to express my appreciation for the opportunity to read your study. You present a comprehensive analysis of the Chinese protected area system and thoughtfully explore how future conservation development should be guided. Your approach not only considers conservation representation within formal protected areas but also emphasizes the critical role of connectivity in sustaining biodiversity into the future. This dual focus demonstrates the ambition and scope of your work, and I commend the effort and depth of analysis that you have undertaken.
That said, I believe there are aspects of the manuscript that would benefit from further clarification. In particular, some elements of the methodological description and the rationale behind certain decisions remain unclear. This lack of clarity not only hinders a complete understanding of your study but also poses challenges for its replication. Addressing these issues would strengthen your contribution significantly and enhance its value to the field.
I have outlined below several points that I hope will serve as constructive feedback to help you refine and elevate your work further. These suggestions are shared in the spirit of supporting the full realization of your study's potential and ensuring its lasting impact.
Thank you for your dedication to this important topic, and I look forward to seeing how your study continues to evolve.

Reply: We are deeply grateful for the time and effort you dedicated to reviewing our manuscript and for providing such thoughtful and constructive feedback. Your insights have been invaluable in improving the clarity and rigor of our work. In response to your suggestions, we have enhanced the methodological descriptions by providing more detailed explanations of each step, including the data sources, framework objectives, and analytical procedures. Furthermore, we have expanded the rationale behind key decisions, offering sufficient context to underscore their validity and relevance to the study's goals. We believe these revisions address your concerns and significantly strengthen the manuscript's contribution to the field. Thank you once again for your guidance, which has greatly improved the quality of our work.

2. ISSUES TO CONSIDER
(1) In title and in parts of the manuscript the term migration is used. I guess that dispersal would be a better term to define it, as migration concerns seasonal movements within a generation of individuals. Dispersal best accommodated populational responses to environmental dynamics.

Reply: We fully agree that "dispersal" is a more precise and scientifically accurate term in

this context. In response, we have replaced “migration” with “dispersal” throughout the manuscript to ensure clarity and alignment with ecological terminology.

(2) The abstract lacks a sentence where the main add ins of the study are clarified and expressed. It only refers to a novel conservation framework, without clarifying where novelty takes part.

Reply: We acknowledge that several existing frameworks also leverage representation and connectivity to identify conservation priorities, which aligns with certain aspects of our work. However, our framework introduces two key advancements that address critical gaps in current approaches. First, we construct a nature conservation network by integrating connectivity analysis with biodiversity prioritization, ensuring cost-effective solutions for conservation planning. Second, we evaluate climate and anthropogenic risks while addressing habitat representation gaps, providing a forward-looking approach to inform future conservation strategies. By integrating connectivity, biodiversity, cost-effectiveness, and exposure risk assessments, our framework offers a more comprehensive and practical tool for expanding formal PAs and identifying informal conservation priority corridors. These integrated dimensions enable a holistic approach to conservation planning, addressing both immediate ecological needs and long-term resilience to global change. We have revised the abstract and provided a detailed explanation in our response to (6) below to further clarify these advancements.

(3) First sentence of the introduction (LINE 51), consider to replace “necessitated” by “triggered”.

Reply: We have replaced "necessitated" with "triggered" as recommended.

(4) In the second paragraph of introduction (LINE 71) there is a mention the principle of conservation priorities. I would say that conservation priorities do not state a principle but rather a purpose or goal. Consider to rephrase to “Addressing this challenge, especially in the light of the unfulfilled Aichi Target 11, highlights the pressing need to establish and address spatial conservation priorities”.

Reply: We have revised the sentence as per suggested by you.

(5) LINES 75-77. This sentence is unclear. For example, what resilient buffer mean? If you intend to refer to combine biodiversity representation with connectivity, consider to be more explicit.

Reply: We have revised this section to more clearly articulate the distinctions between PAs

and priority areas in terms of their conservation goals, as well as the legal and policy constraints that govern them. The revised text emphasizes the complementary relationship between PAs and priority areas, illustrating how priority areas serve as informal extensions to PAs. By enhancing connectivity and representation, priority areas bolster the effectiveness of formal conservation networks while operating under more flexible management approaches.

"This approach, establishing and addressing spatial conservation priorities, aims to identify priority areas as flexible, informal pathways that balance biodiversity conservation with economic development, imposing fewer restrictions to human activities compared to formally PAs. However, research on the integration of priority areas as complementary extensions to legally defined PAs remains limited. This gap underscores the urgent need for integrative approaches that reconcile competing land-use demands while optimizing biodiversity protection."

(6) LINES 122-123. Here you refer to novel framework and innovative approach, however I cannot figure out from the text where the novelty is. There are several examples of studies examining protected area representation and connectivity using a different protocol from the one here exposed, but I do not see which is the added value of the study proposed. You need to better clarify it somewhere around here.

Reply: We sincerely appreciate your valuable comments and agree that several studies have investigated PA representation and connectivity to identify conservation priorities, aligning with certain aspects of our work. However, our framework introduces two critical advancements that address key gaps in existing approaches: (1) the construction of a future-oriented nature conservation network that integrates PAs with conservation priority corridors (CPCs), and (2) the assessment of risks to these networks under pressures from anthropogenic activities, climate change, and habitat representation deficiencies. The primary contribution of our study lies in offering a more comprehensive framework, which we demonstrate through the following key aspects:

Connectivity and biodiversity preservation: Our study employs a connectivity model to identify cost-effective connectivity corridors (CCCs) that play a key role in enhancing landscape connectivity. These corridors improve habitat functionality and support species dispersal by providing critical pathways. To prioritize areas with dual importance for biodiversity and connectivity, we overlaid conservation priority zones (CPZs) with CCCs, resulting in the identification of connectivity and biodiversity corridors (CBCs). CBCs are further classified into formal PAs and informal CPCs based on species' ecological needs and dispersal distance gradients. Specifically, PAs provide stable habitats for species requiring strict protection, while CPCs facilitate movement and adaptation for species with broader

habitat requirements or migratory behaviors. Together, these components form an integrated nature conservation network, combining PAs and CPCs to support future landscape conservation planning.

Cost-effectiveness: The connectivity model also identifies least-cost paths (LCPs) between adjacent PAs by minimizing cumulative resistance. The "cost" in LCPs encompasses two dimensions: ecological cost and economic cost. Ecological cost reflects the resistance faced by species moving between PAs, serving as a proxy of the CCCs' effectiveness in maintaining connectivity. Economic cost, on the other hand, accounts for the resources required to conserve CCCs, which tend to increase in areas with higher human activity. By prioritizing CCCs, our framework ensures an optimal balance between ecological and economic considerations, enhancing connectivity while maintaining cost-effectiveness.

Assessment of climate and anthropogenic activity changes and habitat representation deficiencies: Beyond identifying priority conservation areas, our framework incorporates methods to evaluate the impacts of climate change and anthropogenic pressures on these areas. By quantifying exposure to these factors, we analyze their potential effects on habitat representation, providing critical insights for conservation planning.

Given the integration of connectivity, biodiversity, cost-effectiveness, and exposure risk assessments, we believe our framework offers a novel yet practical tool for expanding formal PAs and identifying informal CPCs, thereby addressing current and future conservation challenges in a systematic manner.

(7) LINE 141. As far as I know China does not make public in WDPA database protected area boundaries since 2014. What information did you get from WDPA?

Reply: Thank you for highlighting this important issue. You are absolutely correct that the WDPA database has removed the majority of PA boundaries in China. We were aware of this limitation and made efforts to locate earlier versions of the WDPA database; however, these attempts were unsuccessful. As you may also know, the current WDPA database does retain a small number of protected area records for China. While we collected and examined this fragmented information, it ultimately proved to be of limited utility for our study. To address this, we have revised the manuscript and removed all mentions of the WDPA database.

(8) LINE 169, what do you mean by distribution ranges? Are you referring to movement capabilities of the areas where the species occur? If the last one I do not realize what is that need for, as the connectivity analysis uses as nodes only the protected areas and not species locations.

Reply: Thank you for your comments. You are correct that determining dispersal distance gradients requires only the calculation of the median, mean, and 90th percentile of movement abilities based on the dispersal capabilities of the selected species. This approach provides a robust foundation for our analysis. Notably, no data related to species distribution ranges were utilized in the manuscript.

To avoid any potential confusion or redundancy, we have revised the Methods section to remove all information related to species distribution ranges. Additionally, we have also removed Figure S1 from the supporting information in the original manuscript to ensure clarity and consistency.

(9) LINE 171. The relationship between mean, median and 90th percentile with Dmax scores used is not clear. Is 10Km the mean, 30km the median and 100km the 90th percentile?

Reply: We apologize for the unclear explanation. We have reorganized the Method section to clarify the relationship between the mean, median, 90th percentile, and the Dmax scores. In revised manuscript, we have the Dmax scores and it with a more concise description. The revisions in the following paragraph also include the modifications made in response to your concern (10).

"Dispersal distance play a critical role in determining the corridors that connect adjacent PA patches, enabling wildlife movement within a predefined range. However, defining dispersal distance is inherently challenging due to the variability in movement abilities across species. To address this, we adopted a coarse-filter approach by establishing dispersal distance gradients designed to encompass the movement abilities of a wide range of terrestrial species. Based on previous studies, we set typical dispersal distances at 10, 30, and 100 km, threshold that are known to cover the movement ranges of most terrestrial species. To ensure these gradients are applicability to China, we followed the methodology of Sun et al.3, focusing specifically on terrestrial mammals. Using a list of important habitats for protected terrestrial wildlife species in China (https://www.forestry.gov.cn/search/538542). We identified 126 priority-protected mammals and estimated their movement abilities based on body weight, diet, and other ecological niche parameters through allometric relationships. By aggregating these dispersal distances, we calculated the median, mean, and 90th percentile of movement ability across regions. The results indicate that the calculated values closely align with the predefined dispersal thresholds of 10 km, 30 km, and 100 km, confirming the applicability of these thresholds for studies conducted in China."

(10) LINES 173-180. The values here reported seem a little bit arbitrary and they real condition the results obtained. There is a lack of references in the statements where you

justify the use of the values. For example, why Dmax = 30km is optimal for future PA expansion?

Reply: We sincerely appreciate the reviewer's insightful comments and acknowledge the importance of the issue raised. Similar concerns were also highlighted in comments (13) and comments (14). In response, we have carefully revised the Methods section.

Specifically, the dispersal distance gradients (10 km, 30 km, and 100 km) used in our study are primarily based on findings from previous studies (e.g., Saura et al., 2017; Santini et al., 2013), which have widely applied these gradients to assess connectivity within PA networks. To ensure the applicability of these gradients to our study region in China, we conducted an additional verification process. This involved evaluating the movement abilities of key protected species in China to confirm the suitability of the selected gradients for the regional context. In the revised manuscript, we have clarified and expanded on these justifications, providing relevant references to support our choices for dispersal distances.

Furthermore, we recognize that the statement "Dmax = 30 km as optimal for future PA expansion" was inappropriately included in the Methods section. To address this, we have moved this statement to the first paragraph of the Results section, where we provide a detailed explanation of the rationale for incorporating different CBC scenarios into future PAs or conservation priority corridors (CPCs) based on their performance.

"Three CBCs scenarios identified 1549, 3356, and 6389 corridors, respectively. These corridors collectively covered 7.6%, 20.0%, and 47.8% of China's terrestrial land surface (Table S1). Notably, as dispersal distance increased, the spatial extent of the CBCs expanded, with corridors identified under smaller dispersal distance scenarios nested within those of larger dispersal distance scenarios. Work towards meeting the coverage targets of the Kunming-Montreal Framework simultaneously, given the performance of CBCs in different scenarios in terms of coverage, representation, cost-effectiveness, and connectivity (Fig. 3; Table S2-S4). Integrating the identified CBCs with 30km dispersal distance into the PA networks (30% target candidate PAs) effectively achieved the 30% coverage targets (34%). Similarly, CBCs with 100km dispersal distance were included as CPCs, which acted as informal priority areas beyond the PA networks. Future PA networks and CPCs together achieved more than 50% coverage targets (61.8 %), and such formal and informal networks were jointly defined as nature conservation networks (Fig. 2d)."

Santini, L. *et al.* Ecological correlates of dispersal distance in terrestrial mammals. *Hystrix* **24**, 181-186 (2013). https://doi.org/10.4404/hystrix-24.2-8746

Saura, S., Bastin, L., Battistella, L., Mandrici, A. & Dubois, G. Protected areas in the world's

ecoregions: How well connected are they? *Ecol. Indic* **76**, 144-158 (2017). https://doi.org/10.1016/j.ecolind.2016.12.047

(11) LINES 181-187. This section is particularly troublesome. It is not mentioned how corridors are traced from the resistance values used and therefore how the number of corridors in each region emerge. Still, what PC index and ProtConn inform on, and were them used in the study for whatever reason?

Reply: We sincerely apologize for the lack of clarity and detail in the original text. To address this issue, we have thoroughly revised this section, ensuring that the methods are described with greater precision and that key details previously omitted are now included for improved clarity and comprehensiveness.

"Connectivity "resistance" was modeled using China's human footprint dataset, weighted by slope derived from a digital elevation model (DEM) dataset to account for the combined impact of human activities and steep topography on mammal movement. This resistance surface was used to identify least-cost paths (LCPs) between adjacent PAs by minimizing cumulative resistance. The "cost" associated with LCPs encompasses two dimensions: ecological cost and economic cost. Ecological cost reflects the hypothetical resistance species encounter when moving between PAs, serving as a proxy of CCCs in maintaining landscape connectivity. Economic cost represents the resources required to conserve CCCs, which escalate in areas with higher human activity. By prioritizing CCCs based on these dual dimensions, we enhance connectivity while balancing ecological and economic benefits, ensuring a cost-effectiveness approach to conservation planning.

To assess the priority of these connectivity corridors (referred as "corridor importance" hereafter, see Fig. 2), we defined by the number of overlapping CCCs within a given area. Unlike linear pathways, CCCs span broader regions characterized by a cost gradient (like a spreading watershed). The spatial overlap of CCCs across their coverage areas underscores their significance in enhancing connectivity. Specifically, we delineated CCCs using LCP analysis, which identifies corridors by minimizing cumulative resistance across the landscape. This approach enabled us to quantify corridor importance based on the spatial overlap and distribution of these CCCs within each region, providing a robust framework for prioritizing connectivity conservation efforts."

Additionally, we have provided a more detailed explanation of the PC index and ProtConn, including their definitions, roles, and applications within the context of this study. These clarifications have been incorporated into the "Connectivity" subsection of the "Statistical

Analysis" section to enhance understanding and clarity.

(12) LINES 188-196. As far as I understand I guess that there is no control on habitat similarity r distinctiveness in the analysis. So, in theory you can really get solutions linking patches of same habitat type, although this might be probabilistic unreasonable.

Reply: We appreciate your insightful comments. This section highlights our broader considerations regarding connectivity research. While linking similar habitat types is a common approach in studies focused on specific ecosystems, such as watersheds, marine environments, or forests. It is seldom applied in protected area network studies at regional, national, or global scales. This limitation arises because incorporating complex control variables, such as habitat similarity, significantly increases computational demands, thereby reducing the practicality of such models. Additionally, prioritizing similar habitats may not always align with the overarching goal of enhancing the efficiency of protected area networks for biodiversity conservation. Given these challenges, simplicity and applicability are critical factors in designing connectivity analyses for conservation planning. Our model aims to balance these priorities, ensuring both feasibility and effectiveness in achieving conservation objectives.

(13) LINE 199-206, It is not clear why global conservation frameworks are used here. It lacks an explanation for this! Also what Median_CPC, Mean_CPC and Max-CPC are? Are there reflecting the use of Dmax values? If so, in Dmax you refer to 90th percentile and not the max value. Need some clarification here.

Reply: We sincerely appreciate your valuable comments. In response to your question about the use of global conservation frameworks in this study, we have provided a more detailed explanation in the revised manuscript to clarify the rationale behind their inclusion.

“Connectivity & biodiversity corridors (CBCs) were derived by overlaying CCCs with conservation priority zones (CPZs). To identify CPZs, we employed the methodology of Yang et al.(2020), which involved spatially integrating seven global biodiversity prioritization templates (BH, CE, CPD, EBA, G200, IFL, and KBA) and extracting the CPZs specific to the China region (Fig. S1).”

Additionally, regarding your query about the terms “Median_CPC,” “Mean_CPC,” and “Max_CPC,” we have removed this section in accordance with your suggestion. For further details on these revisions, please refer to our responses to comments (9) and (10).

Yang, R. *et al.* Cost-effective priorities for the expansion of global terrestrial protected areas: Setting post-2020 global and national targets. *Sci. Adv* **6**, eabc3436 (2020). https://doi.org/10.1126/sciadv.abc3436

(14) LINE 208. Again why Mean-CPC was used over the others to express future candidate areas for selection?

Reply: Again, we sincerely apologize for the confusion caused. Please refer to our responses to your comments (9) and (10) for further details on the revision.

(15) LINE 224-225. What it means, Euclidean distance between two orthogonal PCA axes? How that express climate vulnerability?

Reply: We have addressed your concern by providing a detailed explanation in the revised manuscript. Additionally, another reviewer suggested that the term "vulnerability" may not be the most appropriate descriptor for changes driven by climate change and anthropogenic activities. In response to this feedback, we have revised the terminology accordingly. In the updated manuscript, we now directly refer to “climate change and anthropogenic activities” instead of using the phrase “climate and anthropogenic vulnerability.”

“To quantify climate change, we calculated the Euclidean distance between the past and present the positions of each PA within a two-dimensional climate space, defined by PCA1 and PCA2 axes. This distance serves as a measure of the degree of climate shift, with larger distances indicating greater deviations from historical climate conditions and, consequently, higher levels of climate change.”

(16) LINE 230. When mentioned that the inverse of CV (1/CV = mean/stddev) was used as an indicator of vulnerability it means that the more vulnerable areas refer to those with low variance or standard deviation. Please refer to the rationale of that decision!

Reply: We sincerely apologize for the incorrect description in the methods section. The accurate interpretation is that the coefficient of variation (CV, calculated as stddev/mean) represents vulnerability, while its inverse, "1/CV," reflects stability. Furthermore, in response to concerns raised by another reviewer, we re-evaluated the relevance of quantifying "vegetation vulnerability/stability" within the context of climate change and anthropogenic activity. After careful consideration, we concluded that these metrics are not essential to the scope of this study. As a result, we have removed the discussion of "vegetation vulnerability/stability" from the revised manuscript and focused our analysis on habitat

representation, which better aligns with our research objectives. We hope these revisions adequately address your concerns.

(17) LINE 246, what suitability of climate and topographic conditions refer to? Please, clarify!

Reply: To clarify, topographic conditions in our study specifically referred to the topographic position index (TPI), which was explicitly included in our matching process. The mention of "climate conditions" in this context was an error in phrasing, and we have removed it in the revised manuscript.

"The matching process considered five covariates: (1) elevation; (2) slope; (3) topographic conditions (characterized by the topographic position index, TPI); (4) initial climate, human footprint condition; and (5) consensus land cover type."

(18) LINES 249-262. All this paragraph is not particularly understandable for people that do not domain matching analysis. You may consider to simplify it, with less jargon.

Reply: Great point! To enhance clarity and accessibility, we have revised all descriptions related to the matching analysis, simplifying the explanation of the methodology by avoiding unnecessary scientific jargon. While the language has been streamlined, key details about parameter settings have been retained to ensure methodological accuracy and reproducibility.

"To assess and compare climate and anthropogenic changes across current protected areas (PAs) and candidate areas for the 30% conservation target, we employed a statistically matched method. This approach minimizes non-random effects caused by location bias and accounts for contextual biases. For example, PAs are often established in steeper, more remote areas that are less affected by human activities, which can confound observed shifts in climate and human impacts. Using the R package "MatchIt," we employed propensity score matching (PSM) to pair each pixel in current PAs with a similar pixel in candidate PAs or unprotected areas. The matching process considered five covariates: (1) elevation; (2) slope; (3) topographic conditions (characterized by the topographic position index, TPI); (4) initial climate, human footprint condition; and (5) consensus land cover type. For the first three covariates, matching was conducted without replacement using the nearest-neighbor method with a caliper of 0.25 standard deviations of the propensity score, while the last two covariates were matched exactly. To avoid spillover versus leakage effects from PAs, neighboring areas outside each PA boundary were excluded from the matching analysis using QGIS software. All data were standardized to a 1 km resolution for consistency."

(19) LINE 318. In Fig S

Reply: Done as suggested.

(20) FIGURE 1, in the II phase there is a reference to optimization, but as far as I got, there is no formal optimization procedure used in the approach.

Reply: Thank you for highlighting this important point. You are correct that our methodology does not involve a formal optimization process. In response to your feedback, we have replaced the term "optimization" with "systematic conservation planning" to more accurately reflect the approach used in our study.

(21) In supplementary material, FIGURE S1 lacks a legend.

Reply: We have added the legend for Figure S1.

Reply to Reviewer #3

1. Comments: I appreciate the approach in general, with caveats. This work highlights the need for greater PA connectivity and a method for identifying where connectivity should be prioritized. There are a number of issues that do need to be addressed. It also suffers from a lack of proofreading.

Reply: We sincerely appreciate your constructive comments and suggestions on our manuscript. In response to your feedback, we have made significant revisions to enhance the logical structure and methodological clarity of the study. Specifically, the revisions include the following:

1. **Terminology and Definitions**: We have explicitly defined key terms and specific expressions in the Introduction and Methods sections to improve the rigor and precision of our explanations and discussions.
2. **Reorganization of Content**: The fourth paragraph of the Introduction, titled "Protected Area Performance," has been restructured to better align with the study's research objectives and ensure a coherent narrative.
3. **Revised Expression of Vulnerability**: The phrase "climate and anthropogenic activity vulnerability" has been replaced with "climate change and anthropogenic activity" to more accurately reflect the long-term risks posed by climate change and shifts in the intensity of anthropogenic activities on protected areas.
4. **Improved Terminology**: The term "vegetation vulnerability" has been replaced with "habitat representation deficiencies" to better capture the ecological context and focus on the gaps in habitat representation within protected areas.

Regarding your comment on the method of overlaying different conservation prioritizations, we carefully evaluated your proposed approach. While we deeply respect and acknowledge the insightfulness, rationality, and systematic nature of your conservation planning strategy, we ultimately decided to retain the original method due to its applicability within the scope of this study. Although this decision may have certain limitations, we have provided a detailed and reasoned explanation to justify our choice. We hope this clarification addresses your concerns. We are grateful for your valuable input, which has significantly strengthened the quality of our manuscript.

2. Line-by-line comments:

(1) The paper uses a confusing array of similar terms, that are often not defined in the paper:

• Conservation priority corridors (60)

• Conservation priority areas (73)

• Critical global connectivity areas (87)

• Biodiversity hotspots (88)

• Conservation priority zones (94) • Critical connectivity corridors (106)
• Connectivity-based priority conservation areas (125)

Reply: Thank you for identifying the inconsistencies and lack of clear definitions for key terms in our manuscript. We sincerely apologize for this oversight and have addressed these issues in the revised version by providing explicit definitions for all relevant terms to enhance clarity and precision. Below, we outline the specific revisions made in response to your feedback:

Cost-Effective Connectivity Corridors (CCCs): CCCs were identified using connectivity models across dispersal distances of 10, 30, and 100 km thresholds. These thresholds were selected to encompass the movement ranges of most terrestrial species, ensuring the corridors are ecologically meaningful.

Conservation Priority Zones (CPZs): CPZs were derived by overlaying seven globally recognized biodiversity prioritization templates (BH, CE, CPD, EBA, G200, IFL, and KBA). After careful consideration and thorough evaluation, we have decided to retain this method due to its alignment with the study's objectives. A detailed explanation for this decision is provided in lines 199–201 of the revised manuscript. We appreciate your understanding and constructive input.

Connectivity & Biodiversity Corridors (CBCs): CBCs were generated by integrating CCCs with CPZs. These corridors capture regions with high biodiversity importance (quantified by the number of overlapping CPZ templates), high corridor importance (measured by the number of overlapping CCCs within a given area), and minimized costs (both ecological and economic). Ecological cost refers to minimal ecological resistance, while economic cost reflects the resources required for conservation. This approach ensures high efficiency in maintaining connectivity while mitigating the impact of human activities.

Priority Areas: Priority areas are defined as regions critical for achieving biodiversity conservation goals while balancing the costs and benefits of conservation efforts.

Further analyses revealed that CBCs derived from the 30 km dispersal gradient could significantly contribute to achieving the 30% coverage target for formal protected areas by 2030. In contrast, CBCs identified under the 100 km dispersal gradient could be integrated into flexible **conservation priority corridors (CPCs)** to enhance connectivity and complement the existing protected area network. Together, these elements form an integrated **nature conservation network**, comprising both protected areas (PAs) and CPCs, to guide future landscape conservation planning.

Additionally, we have revised the terminology in the Introduction to ensure consistency and eliminate confusion. The term **"critical global connectivity areas"** (Line 87) remains unchanged, as it aligns with the definition provided in Brennan et al.'s[10] article. However, we

have corrected **"Biodiversity Hotspots"** (Line 88) to the more precise term **"key biodiversity areas"** (KBAs). These adjustments, along with the clarifications provided in the revised manuscript, ensure accurate and consistent usage of terminology. Again, we deeply appreciate your constructive feedback, which has significantly improved the clarity and scientific rigor of our manuscript.

10 Brennan, A. *et al.* Functional connectivity of the world's protected areas. *Science* **376**, 1101-1104 (2022). https://doi.org/10.1126/science.abl8974

(2) Line 97 performance of PAs need to be defined – what kind of performance criteria. Management effectiveness, conservation outcome effectiveness, climate stability effectiveness, greenhouse gas mitigation? How can the performance of candidate PA performance be measured?

97-121 I struggle to see why this section on evaluating PA performance is included?

(3) 114-115 from PA performance to PA vulnerability – not the same thing

Reply: We sincerely apologize for the confusion caused by the section on evaluating PA performance and its link to PA vulnerability. In response to your concerns, we have carefully revised the manuscript to address these issues. Specifically, we have removed the section on PA performance, as it was not sufficiently aligned with the core research objectives of our study. Additionally, we have eliminated the discussion on PA vulnerability, as our methodological approach may not accurately capture or reflect true vulnerability.

"Climate change and shifts in anthropogenic activity represent one of the most pressing challenges to contemporary conservation science. These factors pose significant threats to species survival and undermine the effectiveness of PAs as well as broader conservation efforts. For example, climate change triggers changes in ecosystem dynamics, which can reduce habitat quality and increase species vulnerability, thereby compromising the ability of PAs to fulfill their conservation objectives."

(4) 176 "These corridors are critical for balancing human activity and economic development with minimal environmental impact" – I don't think this sentence makes sense and needs to be restated.

Reply: We have deleted the sentence as suggested.

(5) 189 what is meant by "overall efficiency of biodiversity conservation" – this needs to be

defined

Reply: In the revised manuscript, we have refined this phrase to provide greater specificity and clarity. The updated text now reads:

"The connectivity model in this study was designated to enhance the efficiency of the nature conservation network in conserving biodiversity, rather than focusing on linking similar habitat types. Specifically, the model aims to maintain biodiversity and ecological processes by improving connectivity across all suitable habitats, thereby ensuring a more robust and functional conservation network."

(6) 199-201 I recognize that the method of overlaying different conservation prioritizations is already published by Yang et al, but I fundamentally disagree with this method given the extremely different resolutions at which those prioritizations were done – e.g., G200 Ecoregions vs. KBAs. I suppose this comment is simply a personal editorial. I personally think that a better approach would be to use only the fine-scale prioritizations (e.g., KBAs) as part of a systematic conservation planning approach (sensu Margules & Pressey), incorporating a relatively fine-scale national habitat representation layer, to identify the biodiversity priorities, so that habitat representation would drive the prioritization.

Reply: We sincerely appreciate your constructive feedback and valuable suggestions. We fully agree with you regarding the resolution and hierarchical differences among the prioritization layers used in our study. Fine-scale prioritization approaches, incorporating detailed national habitat representation layers, are scientifically robust for identifying biodiversity priorities driven by habitat representation. However, after extensive consideration, we were unable to implement your proposed method in this manuscript. Below, we outline the key reasons for this decision:

Limitations of Key Biodiversity Areas (KBAs) for This Study: Our analysis reveals that KBAs cover a relatively small proportion of China's land area (11.8%), with 43% of these areas overlapping with existing protected areas. The cost-effective connectivity corridors (CCCs) identified in our study span a much broader geographic extent than KBAs, making their integration challenging. This spatial mismatch limits the applicability of KBAs for aligning with the CCCs in our framework.

Global vs. Regional Biodiversity Priorities: KBAs are identified using standardized global criteria, including the presence of globally threatened species, geographically restricted species, significant ecological processes, and ecosystem integrity. However, global KBAs may not fully capture China's unique biodiversity conservation priorities. For instance, the IUCN Red List provides global threat statuses for species but does not account for regional variations in their conservation status. Species in marginal distribution areas, in particular,

may not be adequately represented in global KBAs. Developing a national-scale KBA framework tailored to China's specific biodiversity context would better align with regional conservation priorities. However, establishing such a framework involves addressing complex ecological, political, and logistical challenges, which fall outside the scope of our current study.

Integration of Conservation Prioritization Layers: Although the seven conservation prioritization layers used in this study vary in resolution and hierarchical levels, they collectively represent potential biodiversity priority distributions across China. By integrating these layers into conservation priority zones (CPZs), we can identify broader spatial patterns and priority areas for conservation. These CPZs can be further refined by overlaying them with our finer-resolution CCCs layer, ensuring that the final recommendations are both actionable and relevant to on-the-ground conservation planning.

We have revised Methods section by discussing the limitations of methods of overlaying different conservation prioritizations in this study.

"It is important to acknowledge that our method of overlaying conservation prioritization layers has inherent limitations, primarily due to the varying resolutions and hierarchical differences among these layers (e.g., G200 Ecoregions vs. Key Biodiversity Areas [KBAs]). A more precise alternative would involve utilizing fine-scale prioritizations, such as KBAs, within a systematic conservation planning framework[11] driven by habitat representation. However, this approach was not feasible in our study due to the challenges of integrating KBAs with our geographically widespread cost-effective connectivity corridors (CCCs). Despite these constraints, the integration of multiple prioritization layers in our study offers a broader spatial perspective, which can inform actionable conservation planning efforts."

11 Dong, X. *et al.* Importance of including Key Biodiversity Areas in China's conservation area-based network. *Biol Conserv* **296**, 110676 (2024). https://doi.org/10.1016/j.biocon.2024.110676

(7) 204 "…that combined low cost, high connectivity, and high biodiversity value." But the three scenarios, as far as I can tell, represent three different levels of connectivity (based on three different Dmax dispersal distances), each with its' own cost. So I don't see where the low cost comes in?

Reply: Thank you for your valuable comment. We have thoroughly revised the Methods section to address this issue. In the "Identification of cost-effective connectivity corridors" subsection, we explicitly incorporated low-cost priorities by modeling connectivity resistance using human footprint data and slope. This approach allowed us to identify least-cost paths that account for both ecological and economic constraints. While we did not quantify the cost

of each individual factor in the manuscript, the method inherently represents an optimal low-cost approach, given the dispersal gradient and the integration of key cost-related variables.

"Connectivity "resistance" was modeled using China's human footprint dataset40, weighted by slope derived from a digital elevation model (DEM) dataset41 to account for the combined impact of human activities and steep topography on mammal movement. This resistance surface was used to identify least-cost paths (LCPs) between adjacent PAs by minimizing cumulative resistance. The "cost" associated with LCPs encompasses two dimensions: ecological cost and economic cost. Ecological cost reflects the hypothetical resistance species encounter when moving between PAs, serving as a proxy of CCCs in maintaining landscape connectivity. Economic cost represents the resources required to conserve CCCs, which escalate in areas with higher human activity. By prioritizing CCCs based on these dual dimensions, we enhance connectivity while balancing ecological and economic benefits, ensuring a cost-effectiveness approach to conservation planning."

(8) 225 Climate vulnerability is a measure of how susceptible a system or resource is to the negative effects of climate change – but what you seem to be calculating in the preceding section is a measure of (recent) past climate change for six climate indicators – this is not climate vulnerability, which can only be derived considering particular systems or resources.

Reply: We sincerely apologize for the misuse of the basic concept of climate vulnerability in our manuscript. We recognize that climate vulnerability must be assessed in the context of specific systems or resources, and its calculation typically relies on a comprehensive indicator system, such as the U.S. Climate Vulnerability Index or the Climate-Conflict-Vulnerability Index. However, no high-resolution dataset on climate vulnerability is currently available for China, making it challenging to incorporate such analyses into our gap assessments at the scale of areas inside and outside protected areas (PAs). Furthermore, the vulnerability analyses in our manuscript were designed to provide a rapid and practical approach to identifying the climate change risks faced by PAs, using the simplest and most effective indicators available.

To address these issues and improve clarity, we have revised the Methods section. Specifically, we now use long-term changes in climate conditions (referred to as "climate change") and long-term changes in anthropogenic activity (referred to as "anthropogenic activity change") as proxies to express the potential risks to PAs.

(9) 226-233 It is unclear what the vegetation stability/vegetation vulnerability is meant to represent. You have a separate measure of anthropogenic activity (a proxy for threats to natural ecosystems) and a measure of climate change. What is unique about the vegetation

measure (vs. the other two measures)? The rationale for including this measure is missing. In addition, I am skeptical of whether what is being combined is a meaningful measure of future habitat vulnerability.

Reply: We deeply appreciate and fully agree with your skepticism regarding the relevance of the vegetation measure in our study, particularly its low correlation with the research objectives. In response, we have decided to remove the evaluation of the vegetation measure from the manuscript. Furthermore, to address your concerns about the omission of habitat representation deficiencies and to provide a more comprehensive assessment of ecosystem state, we have incorporated "habitat representation" into the Statistical Analysis subsection of the Methods section. This addition has also been integrated into the overall structure of the article, serving as a complementary foundational perspective to enhance the robustness and relevance of our research.

(10) 257-258 this sentence does not make sense?

Reply: We have deleted the sentence as suggested.

(11) 279 how are you measuring biodiversity conservation value here?

Reply: Here, we have clarified the term "biodiversity conservation values" by explicitly referring to it as "biodiversity importance," which we previously defined in the Methods section as the number of overlapping Conservation Priority Zone (CPZ) templates. To enhance clarity, we have revised the relevant sentence accordingly.

(12) 310 "…established PAs effectively mitigated climate vulnerabilities…" How is this mitigation measured? I am skeptical.

Reply: We have revised the sentence as: *"Although established protected areas (PAs) experienced lower levels of climate change and anthropogenic activities compared to unprotected areas, candidate PAs were subject to greater changes in both climate and anthropogenic activities than current PAs."*

(13) 330-331 "…imperative to prioritize well-connected, expansive habitat networks." "Representative" is missing from this list and is my biggest concern with this paper.

Reply: To address your concerns regarding the omission of habitat representation in our study, we have integrated this critical dimension into our analysis. This addition enhances our evaluation of the performance of nature conservation networks in representing habitats, which aligns with our first objective (Figure 4). Furthermore, habitat representation is now

used to assess the deficiencies associated with the risks posed by climate change and anthropogenic activity changes, as outlined in our second objective (Figure 5).

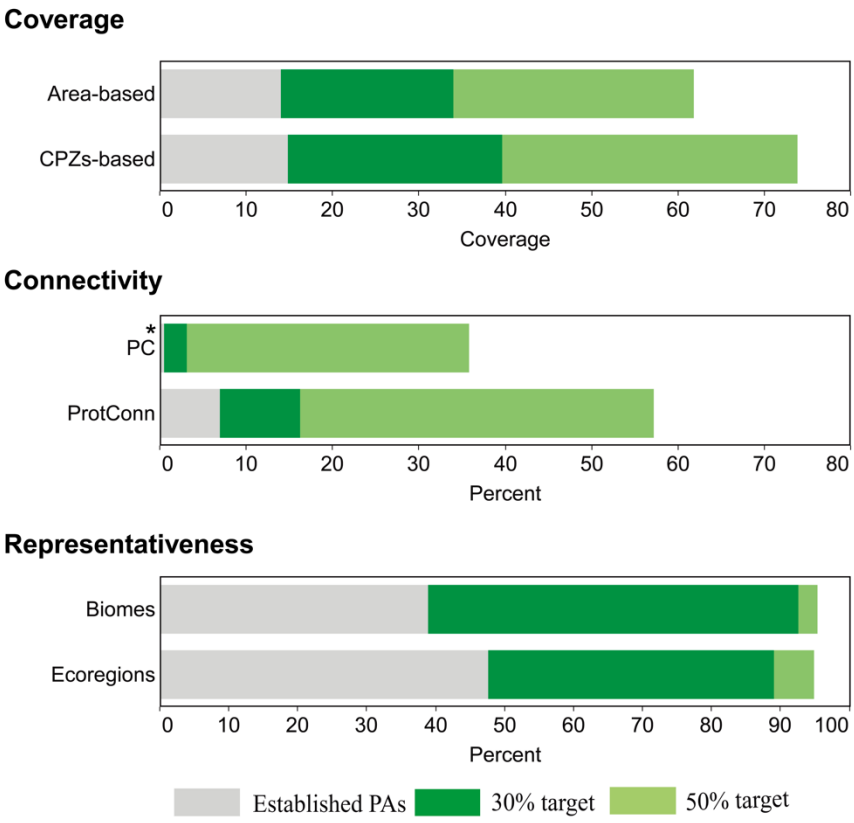

Figure 4 Achievement of coverage, connectivity and habitat representation in multiple scenarios. The achievement of coverage was measured using two metrics: coverage based on the national terrestrial land surface (area-based) and coverage based on conservation priority zones (CPZs-based). The achievement of connectivity was quantified using two metrics: probability of connectivity (PC) and protected connected (ProtConn), which assess connectivity performance. The achievement of habitat representation was evaluated using mean target achievement (MTA), which measures based on biomes and ecoregions. Dark green represents the 30% coverage target achieved by the current and candidate protected areas (PAs). Light green represents the informally conservation priority corridors. Together with the future PA network, they achieve the 50% coverage target.

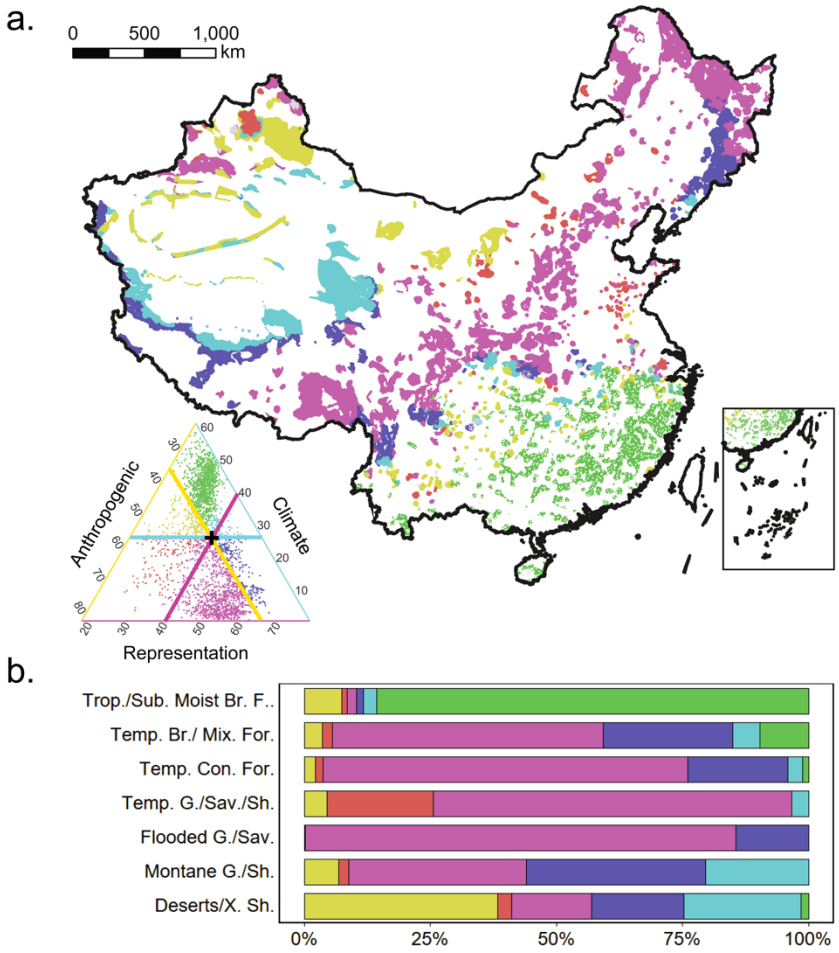

Figure 5 The potential risks and deficiencies facing candidate protected areas. a) Ternary plot showing the intersection of climate, anthropogenic activity risks and habitat representation deficiencies regions. The plus sign (+) in the ternary plot legend shows the intersection of the means of the potential risk and deficiency types. b) Distribution of the potential risks and deficiencies faced by candidate protected areas for each biome in China. **Abbreviations**: Trop./Sub. Moist Br. For., *Tropical and Subtropical Moist Broadleaf Forests*; Temp. Br./Mix. For., *Temperate Broadleaf and Mixed Forests*; Temp. Con. For, *Temperate Coniferous Forests*; Temp. G./Sav/Sh., *Temperate Grasslands, Savannas, and Shrublands*; Flooded G./Sav., *Flooded Grasslands and Savannas*; Montane G./Sh., *Montane Grasslands and Shrublands*; Deserts/X. Sh., *Deserts and Xeric Shrublands*.

Table S3. The achievement of habitat representation based on biomes.

Biomes	Habitat representation		
	Current PAs	Future PAs	Nature conservation networks
Tropical and Subtropical Moist Broadleaf Forests	8.1	31.5	75.4

Temperate Broadleaf and Mixed Forests	9.3	33.5	63.3
Temperate Coniferous Forests	15.1	40.7	64.7
Temperate Grasslands, Savannas, and Shrublands	8.3	21.1	54.7
Flooded Grasslands and Savannas	17.0	34.3	66.2
Montane Grasslands and Shrublands	28.3	47.9	76.7
Deserts and Xeric Shrublands	6.7	21.2	31.8
Mean Target Achievement	**30% target**	**30% target**	**50% target**
	38.9%	92.6%	95.4%

Table S4. The achievement of habitat representation based on ecoregions.

Ecoregions	**Habitat representation**		
	Current PAs	**Future PAs**	**Nature conservation networks**
Alpine cushion vegetation	53%	71%	86%
Alpine sparse vegetation	21%	45%	68%
Alpine tundra	13%	63%	93%
Annual herb deserts	2%	17%	37%
Bamboo forests and scrubs in subtropical and tropical zones	15%	63%	91%
Broadleaf deciduous forests in subtropical zone	18%	56%	88%
Broadleaf deciduous forests in temperate zone	13%	58%	83%
Broadleaf evergreen and deciduous mixed forests in subtropical zone	26%	65%	92%
Broadleaf evergreen and deciduous scrubs in subtropical and tropical zones	9%	32%	75%
Broadleaf evergreen forests in subtropical zone	14%	50%	79%
Cold-temperate and temperate marshes	15%	40%	57%
Cushion nano-semi-shrub high-cold deserts	41%	49%	52%
Deciduous scrubs in temperate zone	10%	40%	76%
Dwarf semi-arboreous deserts	4%	50%	77%

Evergreen xeromorphic succulent thorny scrubs in subtropical and trpical zones	8%	15%	65%
Grass and forb halophytic meadows	7%	27%	45%
Grass and forb meadows	10%	44%	73%
Grass, Carex and forb swamp meadows	14%	32%	60%
Grass, Carex spp. high-cold steppes	50%	70%	88%
High-cold marshes	36%	68%	97%
Kobresia spp., forb high-cold meadows	23%	40%	77%
Microphyllous deciduous woodlands in temperate zone	10%	19%	45%
Needeleleaf, evergreen and deciduous broadleaf mixed forests on mountains in subtropical zone	22%	37%	53%
Needleleaf and deciduous broadleaf mixed forests in temperate zone	19%	93%	98%
Needleleaf forests in cold-temperate zone and on mountains in temperate zone	11%	42%	51%
Needleleaf forests in subtropical zone	9%	41%	83%
Needleleaf forests in temperate zone	9%	20%	50%
Needleleaf forests in tropical zone	66%	98%	98%
Needleleaf forests on mountains in subtropical an tropical zones	26%	64%	92%
Sclerophyllus broadleaf evergreen forests in subtropoical zone	13%	43%	87%
Semi-shrub and dwarf semi-shrub deserts	6%	22%	37%
Shrub deserts	6%	22%	27%
Steppe shrub deserts	5%	16%	22%
Subalpine broadleaf deciduous scrubs	21%	37%	77%
Subalpine needleleaf evergreen scrubs	12%	23%	72%
Subalpine sclerophylla broadleaf evergreen scrubs	19%	48%	91%
Subtropical and tropical grasslands	7%	28%	76%
Subtropical and tropical marshes	13%	48%	70%
Succulent halophytic dwarf semi-shrub deserts	2%	11%	26%
Temperate grass, forb meadow steppes	6%	23%	59%
Temperate grasslands	10%	41%	84%

Temperate tufted grass steppes	8%	17%	52%
Temperate tufted low grass, nano-semi-shrub desert steppes	11%	29%	67%
Tropical mangroves	4%	10%	43%
Tropical monsoon forests	18%	47%	80%
Tropical rain forests	19%	34%	53%
Mean Target Achievement	**30% target**	**30% target**	**50% target**
	47.7%	89.0%	94.9%

(14) 336-337 "…southwestern and southeastern China possess greater biodiversity value." What is this statement based on? Number of species? Number of endemic species? "Biodiversity value" must be defined here. One can argue that all ecoregions possess equal value based on the principle of representivity.

Reply: We sincerely apologize for not defining the relevant terms in our manuscript. In this context, the term "biodiversity value" refers to "biodiversity importance," which we define as the number of overlapping Conservation Priority Zone (CPZ) templates. To address this oversight, we have made the necessary revisions to ensure clarity and consistency throughout the manuscript.

"Our study indicates that existing terrestrial PAs in China are hindered by limited connectivity and insufficient protection of CPZs. There is a significant spatial mismatch between corridor importance areas and biodiversity importance areas, emphasizing the need for region-specific conservation strategies. In northwestern China, characterized by high altitudes and arid climates[54], intact habitats exhibit high connectivity[55] but relatively low biodiversity importance, particularly in terms of species richness and endemism[4]. This suggests that conservation efforts in this region should prioritize maintaining and preventing the degradation of existing corridors[57], which are crucial for sustaining ecological processes in these fragile ecosystems. In contrast, southeastern and southwestern China, with their warm climate, diverse habitats, and exceptional biodiversity significance in terms of high species richness and the presence of threatened species[4,56], face escalating pressures from land-use intensification and urbanization[56]. Here conservation strategies must focus on protecting biodiversity important areas while simultaneously enhancing corridor importance to improve ecosystem function and resilience."

(15) 371-372 "Future PA expansion efforts should focus not only on current human pressures

but also on the vulnerability to human activities." This sentence does not make sense to me. Is the word "future" missing before "human activities"?

Reply: We have removed the sentence as suggested. Furthermore, to provide a more comprehensive analysis, we have included a discussion on the potential reasons for the observed differences in anthropogenic activity levels inside and outside of protected areas.

"Our findings further demonstrate that existing PAs are exposed to anthropogenic disturbances, driven by unpredictable fluctuations in human activity intensity over time. However, these disturbances are significantly lower in PAs compared to candidate PAs and unprotected areas, underscoring their effectiveness in mitigating human impacts. By analyzing the 2000–2018 human footprint dataset, our study provides a comprehensive assessment of conservation outcomes in the 21st century, highlighting the critical role of current PAs in managing anthropogenic pressures. These results not only emphasize the success of existing PAs in reducing disturbances but also underscore the urgent need to address anthropogenic impacts as a central challenge in conservation planning. As the global network of PAs expands, effectively managing these impacts will be essential to ensuring the long-term resilience and functionality of protected ecosystems."

(16) 375 This may be true, but I don't understand how the paper is showing that candidate PAs have greater climate vulnerability than existing PAs.

Reply: Thank you for your valuable comment. To address the issue of climate change, we conducted a matching analysis to compare the potential long-term changes in climate conditions between candidate and existing protected areas (PAs). Our results reveal that candidate PAs face 9.1% higher potential climate change risks compared to existing PAs, as depicted in Figure 6a. This finding underscores the urgency of prioritizing climate adaptation strategies for candidate PAs in future conservation planning efforts.

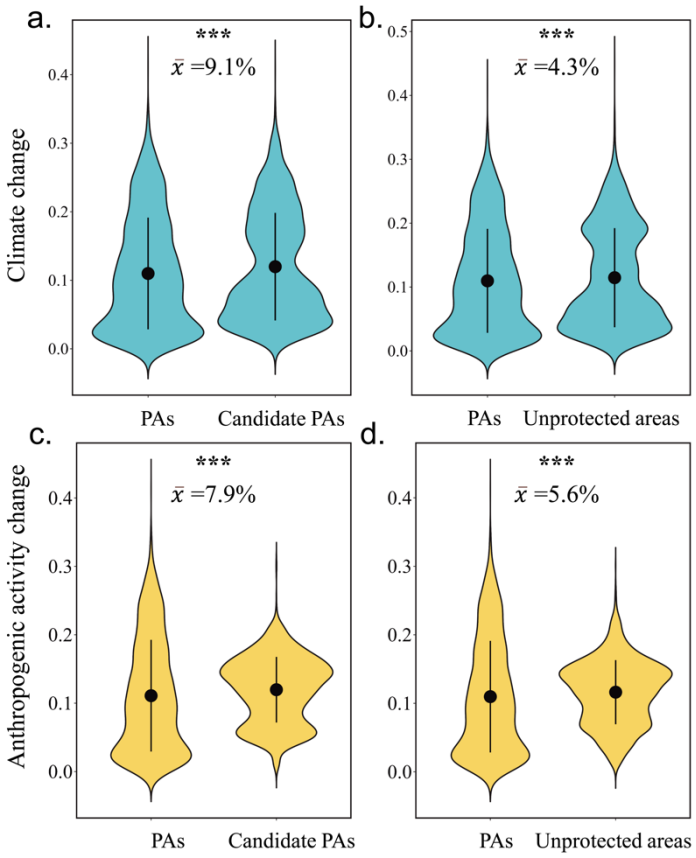

Figure 6 The spatial distribution of climate and anthropogenic activity changes. Violin plots showing (a) climate and (c) anthropogenic activity changes for matched established protected areas (PAs) and unprotected areas (excluding a 1-fold PA buffer), as well as (b) climate and (d) anthropogenic activity changes for matched established and candidate PAs. Points and lines show means and standard deviations, respectively. *P*-values were calculated using Mann-Whitney U tests. $\bar{x}$ represents the percent difference in mean changes.

(17) 385-389 there are repeated sentences in this section

Reply: We apologize for the mistake and have deleted the repeated sentence in the revised manuscript.

Point-by-Point Response

Reply to Reviewer #1

Comments: I would only make a small comment regarding figure 1: you add as a step systematic conservation planning, as you are not applying that approach, I would suggest removing it. Also, the caption of the figure is not appropriate, it is too long the explanation of each of the three components should be self-explained in the figure, and if not, in the text where the figure is cited. These can be applied as well to the caption of Fig. 4

Reply: We sincerely apologize for our misunderstanding of the principles of systematic conservation planning, which resulted in inappropriate usage in our manuscript. In response to this oversight, we have removed the related statements from the text. Furthermore, following your suggestion, we have revised the captions for Figures 1 and 4 to enhance both clarity and conciseness. Specifically, we eliminated the redundant information you highlighted, as it is thoroughly explained in the main text and the Methods section where the figures are cited. Thus, including this information in the figure captions is unnecessary.

Reply to Reviewer #3

1. Comments: I still have questions about the process used to differentiate candidate PAs from corridors. The difference between a candidate PA and a corridor is very unclear to me. The paper talks about candidate PAs and corridors in several places (e.g., line 102 " …it is imperative to expanding PA networks and designing CPCs that…" and lines 319-320 "…When combined, future PA networks and CPCs exceeded the 50% coverage target…"), but I don't see how or where the candidate PAs were identified? Related to this question: the caption for Figure 1 (lines 706-707) references systematic conservation planning - but I don't see systematic conservation planning used in the Methods? (additionally, there is text saying: "However, this approach was not feasible in our study due to the challenges in integrating KBAs with our geographically widespread CCCs." – So I am confused whether systematic conservation planning (Sensu Margules & Pressey) was used or not).

I would have expected that the use of systematic conservation planning would expand the PA network using representation targets, and then the CPCs would connect the resulting new network? It is quite possible that I am not understanding the paper and how the candidate PAs are being identified – I have read the paper several times – if I don't understand it then others may also struggle.

Reply: Thank you for your invaluable comments and for your thorough consideration of the conceptual framework of our study. We recognize that our previous wording may not have adequately distinguished candidate protected areas (PAs) from conservation priority corridors

(CPCs), potentially misrepresenting the role of systematic conservation planning. We appreciate the opportunity to clarify two key aspects of our methodology: (1) the differentiation of candidate PAs from CPCs, and (2) the application of systematic conservation planning in our approach.

Differentiating Candidate PAs from CPCs

To address your concern regarding the identification and distinction of candidate PAs from corridors, we have added a new section in the Methods titled "*Planning of Candidate Protected Areas and Conservation Priority Corridors*". We believe this section will effectively address your inquiries.

"Candidate PAs were defined as CBCs identified under a 30 km dispersal distance scenario. These areas were selected based on their high connectivity and biodiversity importance, aligning with the mean dispersal distance of mammals (see "Identification of cost-effective connectivity corridors"). In contrast, CBCs identified under a 100 km dispersal distance were designated as CPCs, which facilitate the dispersal of the majority (90th percentile) of mammalian species. While CPCs are not formally included in the protected area network, they are recognized as priority areas that enhance overall connectivity. The distinction between candidate PAs and CPCs primarily lies in their planning objectives: candidate PAs are designated for inclusion in the protected area network to meet the targets set by the Kunming-Montreal Global Biodiversity Framework (GBF), whereas CPCs are intended to support connectivity beyond the network, thereby contributing to landscape-scale connectivity."

Clarification on the Use of Systematic Conservation Planning

Our study does not adhere to conventional systematic conservation planning, which typically involves first expanding the PA network using representation targets before identifying CPCs to connect the new network. In contrast, both candidate PAs and CPCs in our study were identified primarily based on their connectivity and biodiversity significance.

Moreover, we did not establish explicit representation targets or employ formal optimization procedures, such as those provided by Marxan. The conceptual foundation of our study was not centered on systematic conservation planning; instead, our primary focus was on enhancing connectivity within the PA network and identifying priority conservation areas that facilitate connectivity during PA expansion. Consequently, representation was assessed as an outcome rather than a selection criterion, evaluated only after identifying candidate PAs and CPCs based on connectivity and biodiversity, including cost considerations. Similarly, risk factors affecting PAs were considered post-selection rather than as determining factors.

To avoid any misunderstanding, we have removed references to systematic conservation planning from both Figure 1 and the third paragraph of the Introduction, as our study does not directly apply this approach.

2. More minor comments:
(1) Line 42 – I simply do not understand the concept of "representation deficiencies within candidate PAs". What does this mean? Candidate PAs are usually identified because there are representation deficiencies.

Reply: Thank you for your comment. The term "representation deficiencies" refers to gaps in biodiversity coverage within existing protected areas. Candidate PAs are identified to address these gaps and ensure more comprehensive protection. o clarify this concept, we have revised the sentence as follows:

"While current protected areas mitigate climate and anthropogenic threats, future expansion faces challenges due to geographic variations in these threats and the necessity for adequate representation."

(2) Line 114 – "effetneness"?

Reply: Done.

(3) Lines 456-458 - It is easy to see why candidate PAs could have more anthropogenic change than existing PAs, but why would candidate PAs have more climate change than existing PAs? What is your proposed explanation for this? It is not intuitive – one would assume that climate change would be the same whether a PA has been designated or not.

Reply: Thank you for your valuable comment. We agree that climate change is a regional phenomenon and, in theory, should impact both candidate and existing PAs similarly. However, we prefer to interpret this as a selection bias in the designation of existing PAs. Typically, existing PAs are established in regions characterized by relatively stable climatic conditions and lower exposure to climate change risks. This trend arises because the designation process often prioritizes areas with high biodiversity, ecosystem integrity, and long-term sustainability, which are more frequently found in climatically stable regions. To clarify this point, we have revised the statement as follows:

"This pattern may reflect a selection bias in the historical designation of existing PAs. These areas were often established in regions with high biodiversity, ecosystem integrity, and long-term sustainability, which are more likely to occur in climatically stable environments."

(4) Line 487 – I think the "performance" should be "perform"

Reply: Done.

(5) Figure 4 – I am struggling to interpret the Habitat Representation bar chart. My understanding of the MTA metric is that it needs to be developed separately for each target representation level – i.e., the MTA score for existing PAs, e.g., would be different from a 30% target representation level than for a 50% target representation level. I don't see how you can combine the two different target representation levels into one bar chart?

Reply: We appreciate your valuable feedback regarding Figure 4. We apologize for any confusion caused by the lack of clarity in the bar chart representation. You correctly noted that the MTA score for existing PAs varies according to the target representation level, as detailed in Tables S3 and S4. In the original figure, we combined results from different target representation levels into a single bar chart to facilitate comparisons across scenarios. However, we recognize that this approach may have led to misinterpretation of the data.

To enhance clarity, we have revised the figure caption as follows: "*The MTA metric is calculated based on distinct target representation levels. The separately developed target representation levels are displayed within a single bar chart to ensure consistency in visualization.*"

(6) Figure 5 – I do not see how to interpret the different colors – where is the legend to explain them? What does each point represent? How is representation deficiency calculated for a single point? I am left not understanding the key question: to what extent is each biome represented? I am struggling to interpret this diagram.

Reply: We appreciate your careful review of Figure 5 and your valuable comments. We apologize for any confusion arising from the complexity of the colors and symbols in the figure. In the revised version, we have added a legend and explanatory notes to improve clarity. Below, we provide detailed responses to your inquiries:

Meaning of the Points in the Figure

Each point in the figure represents a candidate conservation area (CBC) identified under the 30 km dispersal distance scenario, with a total of 3,356 overlapping patches designated as candidate protected areas (PAs).

Calculation of Representation Values

The calculation of representation values followed a two-step process. First, we generated a representation map based on ecoregions, encompassing a total of 91 natural vegetation types. The representation value for each ecoregion was calculated using the combined coverage of both existing and candidate PAs. Second, we employed zonal statistics in ArcGIS on the ecoregion representation map to assign representation values to each candidate PA patch. This approach ensured that candidate PAs spanning multiple ecoregions received appropriate representation values. We have incorporated an explanation of this process for Figure 5 in the Methods section, as follows:

"Additionally, the representation values in Figure 5 were determined through a two-step process. First, we created a representation map based on ecoregions (see Fig. S2). The representation value for each ecoregion was calculated using the combined coverage of existing and candidate PAs. Each point in the figure represents a candidate PA patch, formed by merging spatially adjacent and overlapping areas. Second, we utilized this ecoregion representation map to perform zonal statistics in ArcGIS, assigning a representation value to each candidate PA patch. This approach ensured that patches spanning multiple ecoregions received appropriate representation values."

Revision of Overlapping Areas

During this revision, we recognized that visualizing CBCs as individual points could lead to overlaps. To mitigate this issue, we have made proactive modifications. Instead of representing each CBC as a separate point, we now display merged candidate PA patches. This adjustment reduces the number of points from 3,356 to 689, while maintaining the integrity of our main conclusions.

Representation of Biomes and Ecoregions

For further reference, the representation values for each biome and ecoregion are presented in Tables S3 and S4 in the supplementary materials.

We appreciate your insightful comments, which have significantly contributed to enhancing the clarity of our figure and its accompanying explanation.

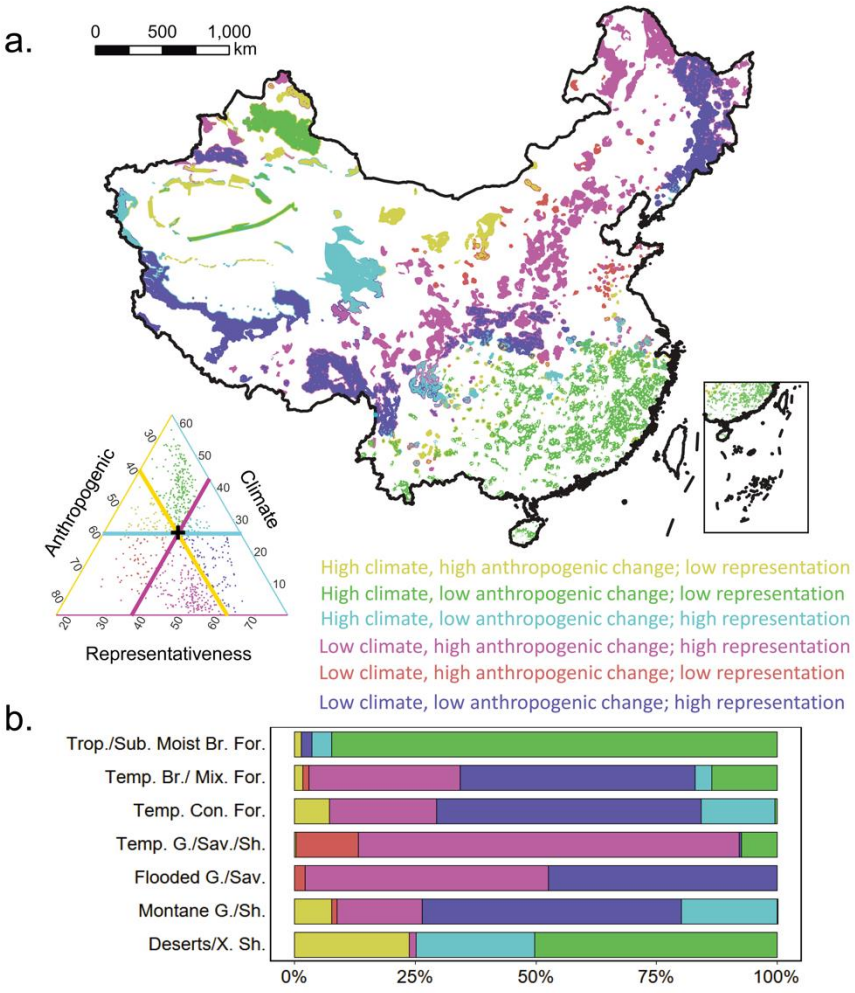

Fig. 5 The potential risks and deficiencies facing candidate protected areas. a) Ternary plot showing the intersection of climate, anthropogenic activity risks and habitat deficiencies regions. Each point in the figure represents a candidate protected area patch formed by merging spatially adjacent and overlapping regions. In total, there are 689 points included in the representation. The plus sign (+) in the ternary plot legend shows the intersection of the means of the potential risk and deficiency types. b) Distribution of the potential risks and deficiencies faced by candidate protected areas for each biome in China.
Abbreviations: Trop./Sub. Moist Br. For., *Tropical and Subtropical Moist Broadleaf Forests*; Temp. Br./Mix. For., *Temperate Broadleaf and Mixed Forests*; Temp. Con. For, *Temperate Coniferous Forests*; Temp. G./Sav/Sh., *Temperate Grasslands, Savannas, and Shrublands*; Flooded G./Sav., *Flooded Grasslands and Savannas*; Montane G./Sh., *Montane Grasslands and Shrublands*; Deserts/X. Sh., *Deserts and Xeric Shrublands*.