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Network ecology in dynamic landscapes

Marie-Josée Fortin, Mark R. T. Dale and Chris Brimacombe

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3rd revised submission:	31 March 2021
Final acceptance:	1 April 2021

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

Review History

RSPB-2020-1889.R0 (Original submission)

Review form: Reviewer 1

Recommendation
Major revision is needed (please make suggestions in comments)

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

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

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

Is the length of the paper justified?
Yes

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

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

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

Is it accessible?
N/A

Is it clear?
N/A

Is it adequate?
N/A

Do you have any ethical concerns with this paper?
No

Comments to the Author
In this review, the authors discuss an approach to integrating ecological networks (e.g., food webs, plant-pollinator networks) with spatial networks to better understand the dynamics of ecological systems. The authors first review different types of networks in ecology and then develop a hypothesis/framework based on the idea of dynamics "on" or "of" the network that they call the ecological network dynamics hypothesis (ENDH). Overall, the idea of better understanding ecological networks by incorporating spatial and temporal dynamics is at the forefront of network ecology. The ideas presented in this manuscript can move the field of network ecology forward. However, I do not feel that they are presented in a clear way. Specifically, the manuscript feels like it is caught in the middle between a conceptual review and a methods paper. The ideas and the figures are not presented clearly enough to hammer home the concepts the authors are trying to get across. In my opinion, you almost want the new ideas to be presented in caricature form so that they are easily visualized and digested by all readers, including those who are not network ecologists. On the other hand, the authors provide what seems to be a new method that "combines filtering the ecological interaction network based on motifs with the delineation of patches in the spatial network using an edge detection algorithm scalable to species dispersal abilities" (lines 19-21). However, there are no clear methods on how to do this analysis, there is not an application of the analysis (simulation or simple data set) that walks one through what to do and what it means, and finally it is not clear what the outcome of such an analysis and how it would give insight into network dynamics. Further, the figures (which are very visually appealing) do not do a compelling job supporting the authors review/concepts. As written, I do not think this paper will have its intended effect of moving the field forward. I think the authors need to decide on either a methods paper where they expound upon the new approach with simulation data of a simple example to show the assumptions, implementation, results, and insights gained. On the other hand, if the authors want to keep it as a concept piece, they need to really clarify the question, the solution, and the implications in a straightforward way.

Detailed comments:

-Lines 58-64. I do not agree that all network metrics and model are based on the degree of the node. For example, there is no clear connection between the degree of a node and the often-used metric of connectance (L/S2). Connectance can remain the same while the degree of all nodes or individual nodes may take different values. There is no way to obtain the degree for a node from connectance. Certainly, the degree of nodes plays some role in the connectance of a network but I do not get the statement that all network metrics and model are based on the degree of the node.

-Lines 64-70. Further, I would not characterize "two main analyses" based on network metrics as the authors do. Futher the characterization of those two analyses is not clear. In my view, there are three types of analysis based on metrics; 1) whole network metrics- analyses that seek to describe patterns and relationships at the scale of the entire network (e.g., connectence, nestedness), 2) subnetwork metrics- analyses that seek to describe patterns and relationships of subgroups of nodes and edges in a network (e.g., motifs, and 3)node-based analysis – analyzing the characteristics of node attributes in a networks (e.g., trophic level, centrality).

-Dynamics "on" and "of" the network.

I like this idea but wonder if this dichotomy represents a gradient and thus if there is really a clear distinction. If changes in node weights (e.g., abundance of a species in a food web) are considered a dynamic "on" the network, what if the abundance of a species changes to zero (i.e., the species is extirpated and the node is no longer present in the network)? Is this then considered dynamics "of"? The same argument can be made for links.

-The "Ecological Network Dynamics Hypothesis" is that "constraints due to species traits…limit how species can respond to changes in network topologies" Lines 230-232. This hypothesis is ambiguous and difficult to assess. Does this have to be tested in a multi-layer framework? The hypothesis is supposed to identify trade-offs that maintain species in the face of spatial dynamics. However, such tradeoffs are not identified. Nor is it clear how they would be identified. Table 1 has a section labeled tradeoffs, but I do not see them as tradeoffs. For example, the first two bullets in the trade-offs section under "Species traits as links" is:

"Long-distance dispersers, species with high dispersal rates, and generalists will persist longer in dynamic landscapes because of their higher probability of reaching habitat patches"

and

"Distance-limited, slow dispersal species, specialists, and species with long generation time or low reproductive rate will persist only when the numbers of nodes and links are high"

Maybe I am missing something here, but I do not see a trade-off. There is no downside to being a long distance disperser/ high dispersal rate/generalist in this statement. Similarly, there is no upside to being a distance-limited, slow dispersal species, specialists, and species with long generation time or low reproductive rate.

In my mind, a trade-off would have to be something like long distance and frequent dispersers are bad competitors and thus are only maintained in early temporal sequences of networks.

Or

Poor dispersers are good competitors, such that when they do disperse, they always establish and are maintained in the local network.

The trade-offs don't seem like trade-offs to me and thus the ability of the ENDH to identify trade-offs in unclear.

-Motif analysis

How does the motif analysis play into the ENDH hypothesis? It is not clear at all and Figure 5 does not really help describe the analysis. Are they structural motifs or are they instances of particular motifs (i.e., with particular species present in the motif)? How is the analysis coupled with spatial analysis to answer a specific question? What does the output look like?

-Comparing networks

It is not clear what is gained by this method and framework for comparing networks. It seems like the authors are advocating for comparing multiple metrics (lines 284-298), which is commonly done (e.g., Dunne et al 2002) in network ecology. Here, a situation with a nice clear example using empirical data or simulated data where the authors walk the reader through the question (what to compare), the methods, and interpretation of results would be very effective. Dunne, J. A., Williams, R. J., & Martinez, N. D. (2002). Food-web structure and network theory: the role of connectance and size. Proceedings of the National Academy of Sciences, 99(20), 12917-12922.

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This section simply seems like a (valid) critique of network ecology but does not really fit in with the manuscript as I see it. Will the authors new approach help mitigate this issue? How? It seems like an add-on section that just states the idea that we need better data.

-Tables and Figures

Table 1 This table is formatted poorly and not very informative. How does the species as nodes fit into the "species trait" definition in the table header? Is that the definition of trophic level in parentheses? "Patches as nodes section needs to be reformatted like the rest of the table. As I wrote earlier, the tradeoffs don't seem like tradeoffs to me.

Figure 1. The example of the temporal network is not clear. The nodes labeled as "a, b, c, d" do not give a clear indication of a temporal network. Having a timeline (e.g., t1,t2,t3…) next to the nodes or labeling the nodes as temporal in some way would be more intuitive.

Figure 2: This figure is not entirely clear and there is not much supporting text in the figure heading. Why are the nodes different colors and sizes? Why are there two layers for the "ecological processes" networks. The feedback arrows are not described at all. I certainly can imagine feedbacks between these different processes/boxes. But they are not talked about it the figure legend or in the text where figure 2 is referenced. Concrete examples would be helpful to make the links for the reader.

Figure 5 seems really important but is not entirely clear. What is going on here. The analysis pipeline is not described at all in the main text, figure, or figure legend. I feel like the authors need to walk the reader through what is going on here in the main text while referencing the figure. In this case an actual example analysis would be useful, even a simplified simulated data set. It is also not clear what figure 5b is showing.

Figure 6. Is this the result of the new of analysis/framework? These don't seem multi-layered. They just seem like regular networks that are compared using previous techniques (e.g., multiple metrics). How will the new method facilitate network comparison?

Review form: Reviewer 2

Recommendation
Accept with minor revision (please list in comments)

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

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

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

Is the length of the paper justified?
Yes

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

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

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Is it accessible?
N/A

Is it clear?
N/A

Is it adequate?
N/A

Do you have any ethical concerns with this paper?
No

Comments to the Author
The authors of RSPB-2020-1889 present an interesting review of recent work and synthesis of ideas related to dynamics in and on ecological networks. A nice feature of this paper is the effort to bring together different elements of network ecology, especially food webs and spatial networks which are often treated separately. Several ideas emerge, such as the Ecological Network Dynamics Hypothesis, that will need further investigation. Overall, the paper was interesting and presented intriguing ideas, and I look forward to seeing where these musing go in future work.

Let me offer a couple of critiques the authors might use to improve the paper in revision.

1. ENDH. I am intrigued by the Ecological Network Dynamics Hypothesis. As stated this seems to provide a road map for future work to better understand the constraints of species abilities on the network topologies and how the topologies can change, and how the species can respond to the changing topologies. However, I am wondering if this is a true hypothesis – can it be falsified? It would be helpful if the authors could expand their consideration of when and how this hypothesis might not be true, or what evidence would falsify it.
2. The ideas and issues in Section 8 and 9 are important for network ecology and for dynamic networks. However, these elements will not be surprising to researchers working in this area.
3. The figure legends are terse, and in many cases the figures really need more description to be understandable, especially as stand-alone elements. I am not sure I fully understand Figure 3 a and b, and Figure 5 is still a bit of a mystery

Decision letter (RSPB-2020-1889.R0)

02-Sep-2020

Dear Dr Fortin:

Your manuscript has now been peer reviewed and I apologise that this has taken longer than usual, a combination of people being frazzled with the stresses of COVID and (hopefully!) attempts to take some form of holiday. The reviewers' comments (not including confidential comments to the Editor) are included at the end of this email for your reference. As you will see, the reviewers have raised some concerns with your manuscript and we would like to invite you to revise your manuscript to address them. In particular, referee 1 thinks the ms tends to fall between two stools -- conceptual review vs methods recommendations -- and this detracts from the clarity of the message. I tend to agree, even though I can appreciate why you might want to cover both aspects, but I would recommend shifting he balance towards the conceptual, as Proceedings B is a broad-readership journal.

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

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

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

Your main manuscript should be submitted as a text file (doc, txt, rtf or tex), not a PDF. Your figures should be submitted as separate files and not included within the main manuscript file.

When revising your manuscript you should also ensure that it adheres to our editorial policies (https://royalsociety.org/journals/ethics-policies/). You should pay particular attention to the following:

Research ethics:
If your study contains research on humans please ensure that you detail in the methods section whether you obtained ethical approval from your local research ethics committee and gained informed consent to participate from each of the participants.

Use of animals and field studies:
If your study uses animals please include details in the methods section of any approval and licences given to carry out the study and include full details of how animal welfare standards were ensured. Field studies should be conducted in accordance with local legislation; please include details of the appropriate permission and licences that you obtained to carry out the field work.

Data accessibility and data citation:

It is a condition of publication that you make available the data and research materials supporting the results in the article (https://royalsociety.org/journals/authors/author-guidelines/#data). Datasets should be deposited in an appropriate publicly available repository and details of the associated accession number, link or DOI to the datasets must be included in the Data Accessibility section of the article (https://royalsociety.org/journals/ethics-policies/data-sharing-mining/). Reference(s) to datasets should also be included in the reference list of the article with DOIs (where available).

In order to ensure effective and robust dissemination and appropriate credit to authors the dataset(s) used should also be fully cited and listed in the references.

If you wish to submit your data to Dryad (http://datadryad.org/) and have not already done so you can submit your data via this link
http://datadryad.org/submit?journalID=RSPB&manu=(Document not available), which will take you to your unique entry in the Dryad repository.

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

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

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

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

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

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

Best wishes,
Innes Cuthill

Prof. Innes Cuthill
Reviews Editor, Proceedings B
mailto: proceedingsb@royalsociety.org

Reviewer(s)' Comments to Author:
Referee: 1
Comments to the Author(s)
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Detailed comments:

-Lines 58-64. I do not agree that all network metrics and model are based on the degree of the node. For example, there is no clear connection between the degree of a node and the often-used metric of connectance (L/S2). Connectance can remain the same while the degree of all nodes or individual nodes may take different values. There is no way to obtain the degree for a node from connectance. Certainly, the degree of nodes plays some role in the connectance of a network but I do not get the statement that all network metrics and model are based on the degree of the node.

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Referee: 2

Comments to the Author(s)
The authors of RSPB-2020-1889 present an interesting review of recent work and synthesis of ideas related to dynamics in and on ecological networks. A nice feature of this paper is the effort to bring together different elements of network ecology, especially food webs and spatial networks which are often treated separately. Several ideas emerge, such as the Ecological Network Dynamics Hypothesis, that will need further investigation. Overall, the paper was interesting and presented intriguing ideas, and I look forward to seeing where these musing go in future work.

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3. The figure legends are terse, and in many cases the figures really need more description to be understandable, especially as stand-alone elements. I am not sure I fully understand Figure 3 a and b, and Figure 5 is still a bit of a mystery

Author's Response to Decision Letter for (RSPB-2020-1889.R0)

See Appendix A.

RSPB-2020-1889.R1 (Revision)

Review form: Reviewer 1

Recommendation
Major revision is needed (please make suggestions in comments)

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

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

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

Is the length of the paper justified?
Yes

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

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

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

Is it accessible?
N/A

Is it clear?
N/A

Is it adequate?
N/A

Do you have any ethical concerns with this paper?
No

Comments to the Author
As I indicated in my initial review, the idea of better understanding ecological networks by incorporating spatial and temporal dynamics is at the forefront of network ecology. Some of the ideas presented in this manuscript can move the field of network ecology forward.
Unfortunately, I still do not feel that they are presented in a clear way. First and foremost, is still not clear to me what the "ecological network dynamics hypothesis" is. It is not clearly stated anywhere in the manuscript. As far as I can tell, it is the idea that spatial networks can influence ecological networks and vice versa.

In the introduction (lines 41-44) the authors state: "We propose an "ecological network dynamics hypothesis" that explicitly stresses the role of network structure (e.g. numbers and weights of nodes and links) in constraining potential ecological responses in complex ecological systems."

To me, this is extremely ambiguous and basically states that network structure matters for how networks respond, which does not seem like a novel insight.

I feel that the authors need a clear definition/description of the ENDH hypothesis, clear examples of how it would advance network ecology, and a simple schematic figure all in the intro to set the stage for what it is that the authors want to convey to the readers (i.e., what their perspective is). I feel this base information is essential. As of now, it is a weak/ambiguous introduction followed by a laundry list of network types that are not tied into the main theme of the paper (which is unclear) in any way. The list of network types and brief descriptions and citations of analyses will not be easily accessible to the majority of readers. How these different network types fit into EDNH and how our knowledge of them will be advanced by would be extremely insightful.

I also feel that the paper is still a mix of a methods paper and a perspectives paper that does not achieve much success at either approach. I appreciate that the authors tried to address this issue, but the figures and figure legend are chock-full of jargon and analysis that need more details and examples or simulations (I agree that this is outside the scope of this paper) and again won't be accessible to readers who are not familiar with network ecology or landscape ecology. On the other hand, I don't really feel that the "perspective" of the authors is clear enough in this manuscript to move the field forward. I am interested and knowledgeable in both landscape ecology and network ecology and I do not know what to take from this manuscript. I feel like an in-depth methods paper showing simulations and/or a full analysis of an empirical data set would be really good. And a cleaned-up perspectives paper of exactly what EDNH is, how does it differ from trophic metacommunity ecology (sensu Gravel et al. 2011 and Guzman et al. 2019) and what its contributions to both network ecology and landscape ecology are?

Gravel, D., Canard, E., Guichard, F., & Mouquet, N. (2011). Persistence increases with diversity and connectance in trophic metacommunities. PloS one, 6(5), e19374.

Guzman, L. M., Germain, R. M., Forbes, C., Straus, S., O'Connor, M. I., Gravel, D., ... & Thompson, P. L. (2019). Towards a multi-trophic extension of metacommunity ecology. Ecology letters, 22(1), 19-33.

Decision letter (RSPB-2020-1889.R1)

22-Feb-2021

Dear Dr Fortin:

Your revised manuscript has now been peer reviewed and the romments (not including confidential comments to the Editor) are included at the end of this email for your reference. I only sent the revised ms to one of the original referees, the one who was least happy with the structure and what the ENDH has to offer. As you will see, the reviewer is still not convinced but acknowledges, as do I, that you have made a serious effort to rejig the manuscript and address those concerns. Because of the latter, and the enthusiasm of the other original referee, I am going to provisionally accept your paper, even though referee 1 may well think I have made the wrong decision. But what does need to be done is make it clear exactly what the ENDH is -- indeed, even the original referee 2 said that it wasn't clear that this really was a hypothesis rather than, say, a methodological approach. I have no problem with it being an approach, but if it is a hypothesis, exactly what is that hypothesis and how could it be falsified? No-one is going to argue against ecological systems being networks in both space and time.

We do not normally allow multiple rounds of revision so you really have to fully address the remaining comments at this stage.

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

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

Your main manuscript should be submitted as a text file (doc, txt, rtf or tex), not a PDF. Your figures should be submitted as separate files and not included within the main manuscript file.

When revising your manuscript you should also ensure that it adheres to our editorial policies (https://royalsociety.org/journals/ethics-policies/). You should pay particular attention to the following:

Research ethics:
If your study contains research on humans please ensure that you detail in the methods section whether you obtained ethical approval from your local research ethics committee and gained informed consent to participate from each of the participants.

Use of animals and field studies:
If your study uses animals please include details in the methods section of any approval and licences given to carry out the study and include full details of how animal welfare standards were ensured. Field studies should be conducted in accordance with local legislation; please include details of the appropriate permission and licences that you obtained to carry out the field work.

Data accessibility and data citation:
It is a condition of publication that you make available the data and research materials supporting the results in the article (https://royalsociety.org/journals/authors/author-guidelines/#data). Datasets should be deposited in an appropriate publicly available repository and details of the associated accession number, link or DOI to the datasets must be included in the Data Accessibility section of the article (https://royalsociety.org/journals/ethics-policies/data-sharing-mining/). Reference(s) to datasets should also be included in the reference list of the article with DOIs (where available).

In order to ensure effective and robust dissemination and appropriate credit to authors the dataset(s) used should also be fully cited and listed in the references.

If you wish to submit your data to Dryad (http://datadryad.org/) and have not already done so you can submit your data via this link
http://datadryad.org/submit?journalID=RSPB&manu=(Document not available), which will take you to your unique entry in the Dryad repository.

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

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

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

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

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

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

Best wishes,
Innes Cuthill

Prof. Innes Cuthill
Reviews editor, Proceedings B
mailto: proceedingsb@royalsociety.org

Reviewer(s)' Comments to Author:

Referee: 1

Comments to the Author(s)
As I indicated in my initial review, the idea of better understanding ecological networks by incorporating spatial and temporal dynamics is at the forefront of network ecology. Some of the ideas presented in this manuscript can move the field of network ecology forward. Unfortunately, I still do not feel that they are presented in a clear way. First and foremost, is still not clear to me what the "ecological network dynamics hypothesis" is. It is not clearly stated anywhere in the manuscript. As far as I can tell, it is the idea that spatial networks can influence ecological networks and vice versa.

In the introduction (lines 41-44) the authors state: "We propose an "ecological network dynamics hypothesis" that explicitly stresses the role of network structure (e.g. numbers and weights of nodes and links) in constraining potential ecological responses in complex ecological systems." To me, this is extremely ambiguous and basically states that network structure matters for how networks respond, which does not seem like a novel insight.

I feel that the authors need a clear definition/description of the ENDH hypothesis, clear examples of how it would advance network ecology, and a simple schematic figure all in the intro to set the stage for what it is that the authors want to convey to the readers (i.e., what their perspective is). I feel this base information is essential. As of now, it is a weak/ambiguous introduction followed by a laundry list of network types that are not tied into the main theme of the paper (which is unclear) in any way. The list of network types and brief descriptions and citations of analyses will not be easily accessible to the majority of readers. How these different network types fit into EDNH and how our knowledge of them will be advanced by would be extremely insightful.

I also feel that the paper is still a mix of a methods paper and a perspectives paper that does not achieve much success at either approach. I appreciate that the authors tried to address this issue, but the figures and figure legend are chock-full of jargon and analysis that need more details and examples or simulations (I agree that this is outside the scope of this paper) and again won't be accessible to readers who are not familiar with network ecology or landscape ecology. On the other hand, I don't really feel that the "perspective" of the authors is clear enough in this manuscript to move the field forward. I am interested and knowledgeable in both landscape ecology and network ecology and I do not know what to take from this manuscript. I feel like an in-depth methods paper showing simulations and/or a full analysis of an empirical data set would be really good. And a cleaned-up perspectives paper of exactly what EDNH is, how does it differ from trophic metacommunity ecology (sensu Gravel et al. 2011 and Guzman et al. 2019) and what its contributions to both network ecology and landscape ecology are?

Gravel, D., Canard, E., Guichard, F., & Mouquet, N. (2011). Persistence increases with diversity and connectance in trophic metacommunities. PloS one, 6(5), e19374.

Guzman, L. M., Germain, R. M., Forbes, C., Straus, S., O'Connor, M. I., Gravel, D., ... & Thompson, P. L. (2019). Towards a multi-trophic extension of metacommunity ecology. Ecology letters, 22(1), 19-33.

Author's Response to Decision Letter for (RSPB-2020-1889.R1)

See Appendix B.

RSPB-2020-1889.R2 (Revision)

Review form: Reviewer 3 (Jinbao Liao)

Recommendation
Reject – article is not of sufficient interest (we will consider a transfer to another journal)

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

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

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

Is the length of the paper justified?
Yes

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

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

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

Is it accessible?
N/A

Is it clear?
Yes

Is it adequate?
Yes

Do you have any ethical concerns with this paper?
No

Comments to the Author
This manuscript by Fortin et al. is a review paper that focused on the dynamics of ecological networks in response to environmental changes. This review has some similarities with the paper published in Nature Ecology & Evolution (Pilosof et al. 2017). Thus, I strongly suggest that they should clarify what their perspective beyond it. In particular, the authors just simply summarized previous studies, while only little work referred to the future direction/suggestion at the end of this paper. They should offer insights on future research directions beyond a literature review, which is most important point for review paper. After going through this whole text, I don't think this review meets the basic requirement.

Decision letter (RSPB-2020-1889.R2)

29-Mar-2021

Dear Dr Fortin

RSPB-2020-1889.R2 entitled "Network Ecology in Dynamic Landscapes" has been accepted for publication in Proceedings B.

The original referee whose criticisms you were addressing in your revision declined the request to review it, so we sought another opinion. However, referee 3 doesn't really think your article has enough novel ideas to warrant publishing in Proceedings B. This is, of course, a rather tricky situation and I apologise to the new referee for not making it clear that the submission had already been through two rounds of review, with one very positive referee's report in round 1, and a negative report that the two subsequent revisions attempted to address. Given that I feel it would be very unfair to reject your manuscript when I had indicated that the final revisions were not of a substantive nature, I am now accepting your manuscript -- even though the new referee will disagree. As referee 3's negative report relate to the balance of the article -- too much review not enough novelty -- rather than any errors in the science, I will put this down to a difference of opinion and, again, apologise to the referee for not making the wider context clear.

Therefore, I invite you to upload the final version of your manuscript. Because the schedule for publication is very tight, it is a condition of publication that you submit the final version of your manuscript within 7 days. If you do not think you will be able to meet this date please let us know.

To upload your manuscript, log into https://mc.manuscriptcentral.com/prsb and enter your Author Centre, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision. You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript and upload a new version through your Author Centre.

Before uploading your revised files please make sure that you have:

1) A text file of the manuscript (doc, txt, rtf or tex), including the references, tables (including captions) and figure captions. Please remove any tracked changes from the text before submission. PDF files are not an accepted format for the "Main Document".

2) A separate electronic file of each figure (tiff, EPS or print-quality PDF preferred). The format should be produced directly from original creation package, or original software format. PowerPoint files are not accepted.

3) Electronic supplementary material: this should be contained in a separate file and where possible, all ESM should be combined into a single file. All supplementary materials accompanying an accepted article will be treated as in their final form. They will be published alongside the paper on the journal website and posted on the online figshare repository. Files on figshare will be made available approximately one week before the accompanying article so that the supplementary material can be attributed a unique DOI.

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

4) A media summary: a short non-technical summary (up to 100 words) of the key findings/importance of your manuscript.

5) Data accessibility section and data citation
It is a condition of publication that data supporting your paper are made available either in the electronic supplementary material or through an appropriate repository (https://royalsociety.org/journals/authors/author-guidelines/#data).

In order to ensure effective and robust dissemination and appropriate credit to authors the dataset(s) used should be fully cited. To ensure archived data are available to readers, authors should include a 'data accessibility' section immediately after the acknowledgements section. This should list the database and accession number for all data from the article that has been made publicly available, for instance:
• DNA sequences: Genbank accessions F234391-F234402
• Phylogenetic data: TreeBASE accession number S9123
• Final DNA sequence assembly uploaded as online supplemental material
• Climate data and MaxEnt input files: Dryad doi:10.5521/dryad.12311
NB. From April 1 2013, peer reviewed articles based on research funded wholly or partly by RCUK must include, if applicable, a statement on how the underlying research materials – such as data, samples or models – can be accessed. This statement should be included in the data accessibility section.

If you wish to submit your data to Dryad (http://datadryad.org/) and have not already done so you can submit your data via this link
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take you to your unique entry in the Dryad repository. If you have already submitted your data to dryad you can make any necessary revisions to your dataset by following the above link. Please see https://royalsociety.org/journals/ethics-policies/data-sharing-mining/ for more details.

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

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

Best wishes,
Innes Cuthill

Prof. Innes Cuthill
Reviews Editor, Proceedings B
mailto: proceedingsb@royalsociety.org

Reviewer(s)' Comments to Author:

Referee: 3
Comments to the Author(s)
This manuscript by Fortin et al. is a review paper that focused on the dynamics of ecological networks in response to environmental changes. This review has some similarities with the paper published in Nature Ecology & Evolution (Pilosof et al. 2017). Thus, I strongly suggest that they should clarify what their perspective beyond it. In particular, the authors just simply summarized previous studies, while only little work referred to the future direction/suggestion at the end of this paper. They should offer insights on future research directions beyond a literature review, which is most important point for review paper. After going through this whole text, I don't think this review meets the basic requirement.

Decision letter (RSPB-2020-1889.R3)

01-Apr-2021

Dear Dr Fortin

I am pleased to inform you that your manuscript entitled "Network ecology in dynamic landscapes" has been accepted for publication in Proceedings B.

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

If you are likely to be away from e-mail contact during this period, let us know. Due to rapid publication and an extremely tight schedule, if comments are not received, we may publish the paper as it stands.

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Your article has been estimated as being 10 pages long. Our Production Office will be able to confirm the exact length at proof stage.

Data Accessibility section
Please remember to make any data sets live prior to publication, and update any links as needed when you receive a proof to check. It is good practice to also add data sets to your reference list.

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The open access fee is £1,700 per article (plus VAT for authors within the EU). If you wish to opt for open access then please let us know as soon as possible.

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An e-mail request for payment of any related charges will be sent out shortly. The preferred payment method is by credit card; however, other payment options are available.

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

You are allowed to post any version of your manuscript on a personal website, repository or preprint server. However, the work remains under media embargo and you should not discuss it with the press until the date of publication. Please visit https://royalsociety.org/journals/ethics-policies/media-embargo for more information.

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

Sincerely,
Proceedings B
mailto: proceedingsb@royalsociety.org

Appendix A

January 19, 2021

Network Ecology in Dynamic Landscapes (RSPB-2020-1889)

**We are grateful for the thoughtful and constructive feedback that we received from you and both reviewers. We also thank the editor and the referees for their patience as we revised the manuscript. We carefully considered all recommendations and made several major changes in this revision while maintaining focus on the main objective, which we believe have substantially improved the manuscript. We begin by highlighting those major changes here as there were some common threads throughout the reviews:

- We added a co-author: Chris Brimacombe.
- We reorganized and rewrote most of the manuscript: we removed the Sampling Issues Section and replacing it with a new section entitled Inferring
- We removed all the six original figures and replaced them with new five figures and one as supplementary material.
- We removed Table 1.
- We clarify our formulation of the Ecological Network Dynamics Hypothesis by adding a new figure (Figure 4) and presenting examples of testable predictions.
- We added a cartoon example of ecological network dynamics analysed using directed graphlets.
- We clarify how the identification of functional spatial ecological networks can be achieved by integrating of interaction network and spatial network.

Below, we detailed our revisions and hope our responses satisfy your concerns.

Referee 1:

In this review, the authors discuss an approach to integrating ecological networks (e.g., food webs, plant-pollinator networks) with spatial networks to better understand the dynamics of ecological systems. The authors first review different types of networks in ecology and then develop a hypothesis/framework based on the idea of dynamics “on” or “of” the network that they call the ecological network dynamics hypothesis (ENDH). Overall, the idea of better understanding ecological networks by incorporating spatial and temporal dynamics is at the forefront of network ecology. The ideas presented in this manuscript can move the field of network ecology forward. However, I do not feel that they are presented in a clear way.

- **Thank you for your thoughtful and constructive feedback. To improve that clarification of our messages that we are promoting in this paper, we revised the entire manuscript by reorganizing the sections.

Specifically, the manuscript feels like it is caught in the middle between a conceptual review and a methods paper.

- **We agree with the Reviewer that our manuscript is not only a review of networks commonly used in ecology but also aims to be a perspective paper by proposing new directions for the field of network ecology, with concrete examples. However, we have also tried to use the "review" material of networks adopted in ecology to more aptly characterize some of the new perspectives we propose, and hope that it makes the new perspectives more digestible to readers.

The ideas and the figures are not presented clearly enough to hammer home the concepts the authors are trying to get across.

- **We rewrote most of the manuscript to clarify the ideas we propose and as such we also changed all figures and removed Table 1. We believe that the new material makes the manuscript stronger, in a way that allows the reader to grasp the concepts more easily.

In my opinion, you almost want the new ideas to be presented in caricature form so that they are easily visualized and digested by all readers, including those who are not network ecologists.

- **This is a good point, and we have tried to accomplish this in the revised manuscript, with all revised figures..

On the other hand, the authors provide what seems to be a new method that "combines filtering the ecological interaction network based on motifs with the delineation of patches in the spatial network using an edge detection algorithm scalable to species dispersal abilities" (lines 19-21). However, there are no clear methods on how to do this analysis, there is not an application of the analysis (simulation or simple data set) that walks one through what to do and what it means, and finally it is not clear what the outcome of such an analysis and how it would give insight into network dynamics.

- **To illustrate how ecological network can be analysed, we added a cartoon example to show how directed graphlets (similar to motifs) could be used to analyse interaction networks along spatial network.

Further, the figures (which are very visually appealing) do not do a compelling job supporting the authors review/concepts. As written, I do not think this paper will have its intended effect of moving the field forward. I think the authors need to decide on either a methods paper where they expound upon the new approach with simulation data of a simple example to show the assumptions, implementation, results, and insights gained. On the other hand, if the authors want to keep it as a concept piece, they need to really clarify the question, the solution, and the implications in a straightforward way.

- **We greatly appreciate all your constructive comments and suggestions, and we hope that the revised version of our manuscript satisfy your concerns. In addition, we believe that your suggestion of adding visual representations (e.g. with examples) of proposed methodological approaches has given the manuscript more rigor for the readers.

Detailed comments:

-Lines 58-64. I do not agree that all network metrics and model are based on the degree of the node. For example, there is no clear connection between the degree of a node and the often-used metric of connectance (L/S2). Connectance can remain the same while the degree of all nodes or individual nodes may take different values. There is no way to obtain the degree for a node from connectance. Certainly, the degree of nodes plays some role in the connectance of a network but I do not get the statement that all network metrics and model are based on the degree of the node.

- **This is a valid point, and we have removed this statement and some of the material presented in Lines 58-64, which can be now found in the new Section 4. Network Properties (Lines 205-250).

-Lines 64-70. Further, I would not characterize "two main analyses" based on network metrics as the authors do. Further the characterization of those two analyses is not clear. In my view, there are three types of analysis based on metrics; 1) whole network metrics- analyses that seek to describe patterns and relationships at the scale of the entire network (e.g., connectence, nestedness), 2) subnetwork metrics- analyses that seek to describe patterns and relationships of subgroups of nodes and edges in a network (e.g., motifs, and 3)node-based analysis – analyzing the characteristics of node attributes in a networks (e.g., trophic level, centrality).

- **We particularly like this suggestion and have revised the manuscript to reflect these three types of analyses . In addition, we have updated the material presented in Lines 64-70 that are now found in the new Section 4. Network Properties (Lines 205-250).

-Dynamics "on" and "of" the network.

I like this idea but wonder if this dichotomy represents a gradient and thus if there is really a clear distinction. If changes in node weights (e.g., abundance of a species in a food web) are considered a dynamic "on" the network, what if the abundance of a species changes to zero (i.e., the species is extirpated and the node is no longer present in the network)? Is this then considered dynamics "of"? The same argument can be made for links.

**We revised this section (now Section 3. Network dynamics and evolution) to address the reviewer's comments.

-The "Ecological Network Dynamics Hypothesis" is that "constraints due to species traits…limit how species can respond to changes in network topologies" Lines 230-232. This hypothesis is ambiguous and difficult to assess. Does this have to be tested in a multi-layer framework? The hypothesis is supposed to identify trade-offs that maintain species in the face of spatial dynamics. However, such tradeoffs are not identified. Nor is it clear how they would be identified. Table 1 has a section labeled tradeoffs, but I do not see them as tradeoffs.

- **We rewrote completely this section (now Section 6. Ecological Network Dynamics Hypothesis; Lines 281-361) and added Figure 4 to clarify what the ENDH entails. Although, we recognize that this hypothesis is hard to test, we advocate that certain broad predications can be made from it—which are included in this section. In addition, we

hope that by defining ENDH, we bring about more work from ecologists and network scientists to help make the hypothesis more *rigorous*.

- We have addressed the issues related to tradeoffs, we removed any reference to them from the manuscript.

For example, the first two bullets in the trade-offs section under "Species traits as links" is:

"Long-distance dispersers, species with high dispersal rates, and generalists will persist longer in dynamic landscapes because of their higher probability of reaching habitat patches"

And

"Distance-limited, slow dispersal species, specialists, and species with long generation time or low reproductive rate will persist only when the numbers of nodes and links are high"

Maybe I am missing something here, but I do not see a trade-off. There is no downside to being a long distance disperser/ high dispersal rate/generalist in this statement. Similarly, there is no upside to being a distance-limited, slow dispersal species, specialists, and species with long generation time or low reproductive rate.

In my mind, a trade-off would have to be something like long distance and frequent dispersers are bad competitors and thus are only maintained in early temporal sequences of networks.

Or

Poor dispersers are good competitors, such that when they do disperse, they always establish and are maintained in the local network.

The trade-offs don't seem like trade-offs to me and thus the ability of the ENDH to identify trade-offs in unclear.

- **We recognize that the tradeoffs were not as clear as we would have like. Hence, we have decided to avoid any confusion by removing "tradeoffs" from the revised version of this manuscript.
- **We removed Table 1.

-Motif analysis

How does the motif analysis play into the ENDH hypothesis? It is not clear at all and Figure 5 does not really help describe the analysis. Are they structural motifs or are they instances of particular motifs (i.e., with particular species present in the motif)? How is the analysis coupled with spatial analysis to answer a specific question? What does the output look like?

- **We revised the following sections: 3. Network dynamics and evolution, 4. Network properties, 6. Ecological Network Dynamics Hypothesis, and 7. Functional spatial ecological networks. We hope that these revised sections and the cartoon example presented in Figure 3 clarify how motifs, graphlets, can be used to test the ENDH.

-Comparing networks

It is not clear what is gained by this method and framework for comparing networks. It seems like the authors are advocating for comparing multiple metrics (lines 284-298), which is commonly done (e.g., Dunne et al 2002) in network ecology. Here, a situation with a nice clear example using empirical data or simulated data where the authors walk the reader through the question (what to compare), the methods, and interpretation of results would be very effective.

Dunne, J. A., Williams, R. J., & Martinez, N. D. (2002). Food-web structure and network theory: the role of connectance and size. Proceedings of the National Academy of Sciences, 99(20), 12917-12922.

- **We removed this section and now have reorganized some aspects presented in this former section, which can be found in the new Section 3: Network dynamics and evolution. Instead of comparing networks, we provide a broad overview of some metrics that can be used to evaluate networks and their evolution.

-Sampling issues

This section simply seems like a (valid) critique of network ecology but does not really fit in with the manuscript as I see it. Will the authors new approach help mitigate this issue? How? It seems like an add-on section that just states the idea that we need better data.

- **We removed this section and now we reorganized some aspects presented in this former section can be found in the new Section 5. Inferring networks. We suggest that some methods of "inferred networks" may be one approach to help reduce sampling issues, e.g. obtaining samples of a broad range of species via abundance counts.

-Tables and Figures

Table 1 This table is formatted poorly and not very informative. How does the species as nodes fit into the "species trait" definition in the table header? Is that the definition of trophic level in parentheses? "Patches as nodes section needs to be reformatted like the rest of the table. As I wrote earlier, the tradeoffs don't seem like tradeoffs to me.

- **We removed Table 1.

Figure 1. The example of the temporal network is not clear. The nodes labeled as "a, b, c, d" do not give a clear indication of a temporal network. Having a timeline (e.g., t1,t2,t3…) next to the nodes or labeling the nodes as temporal in some way would be more intuitive.

- **We modified Figure 1 and it is now showing only a multipartite network and a multilayer network.

Figure 2: This figure is not entirely clear and there is not much supporting text in the figure heading. Why are the nodes different colors and sizes? Why are there two layers for the "ecological processes" networks. The feedback arrows are not described at all. I certainly can imagine feedbacks between these different processes/boxes. But they are not talked about it the

figure legend or in the text where figure 2 is referenced. Concrete examples would be helpful to make the links for the reader.

- **We removed this figure.

Figure 5 seems really important but is not entirely clear. What is going on here. The analysis pipeline is not described at all in the main text, figure, or figure legend. I feel like the authors need to walk the reader through what is going on here in the main text while referencing the figure. In this case an actual example analysis would be useful, even a simplified simulated data set. It is also not clear what figure 5b is showing.

- **We modified this figure and hope that it is clearer.

Figure 6. Is this the result of the new of analysis/framework? These don't seem multi-layered. They just seem like regular networks that are compared using previous techniques (e.g., multiple metrics). How will the new method facilitate network comparison?

- **We removed this figure.

Referee 2:

The authors of RSPB-2020-1889 present an interesting review of recent work and synthesis of ideas related to dynamics in and on ecological networks. A nice feature of this paper is the effort to bring together different elements of network ecology, especially food webs and spatial networks which are often treated separately. Several ideas emerge, such as the Ecological Network Dynamics Hypothesis, that will need further investigation. Overall, the paper was interesting and presented intriguing ideas, and I look forward to seeing where these musing go in future work.

- **We greatly appreciate all your constructive comments and suggestions, and we hope that the revised version of our manuscript satisfy your concerns.

Let me offer a couple of critiques the authors might use to improve the paper in revision.

1. ENDH. I am intrigued by the Ecological Network Dynamics Hypothesis. As stated this seems to provide a road map for future work to better understand the constraints of species abilities on the network topologies and how the topologies can change, and how the species can respond to the changing topologies. However, I am wondering if this is a true hypothesis – can it be falsified? It would be helpful if the authors could expand their consideration of when and how this hypothesis might not be true, or what evidence would falsify it.

- **We revised completely Section 6. Ecological Network Dynamics Hypothesis and improved Figure 5. Although we recognize that this hypothesis is hard to test, we advocate that certain broad predications can be made from it [which are included in this

section]. In addition, we hope that by defining ENDH, we bring about more work from ecologists and network scientists to help make the hypothesis more *rigorous*.

2. The ideas and issues in Section 8 and 9 are important for network ecology and for dynamic networks. However, these elements will not be surprising to researchers working in this area.

- **We agree and as such we removed these sections and reorganized some aspects presented in these former sections can be found in the new Section 5. Inferring networks.

3. The figure legends are terse, and in many cases the figures really need more description to be understandable, especially as stand-alone elements. I am not sure I fully understand Figure 3 a and b, and Figure 5 is still a bit of a mystery.

- **We removed Figure 3. We improved Figure 5 and hope that it is clearer now.

Appendix B

March 23, 2021

Dear Dr. Innes Cuthill

Thank you for the constructive review of our manuscript (RSPB-2020-1889) titled “Network Ecology in Dynamic Landscapes”. We are grateful for the constructive feedback from both the anonymous reviewer and yourself that has considerably improved the presentation of our study. We have addressed all points raised below in the point-by-point response. We made the necessary changes in our revised manuscript accordingly. We highlight here the major changes that we made in our revision based on comments by the reviewer and yourself:

- We removed some sections (2. Network types, 2.1 Species interaction networks, 2.2 Temporal networks, 2.3 Spatial networks).
- We moved Figure 2 to the Supplementary Material. Hence, there is now only three figures in the main text, allowing for more space for a more thorough description of our main thesis.
- And, we clarified our formulation of the Ecological Network Dynamics Hypothesis now referred to as Ecological Network Dynamics Framework.

We hope our responses satisfy your concerns.

Associate Editor:
As you will see, the reviewer is still not convinced but acknowledges, as do I, that you have made a serious effort to rejig the manuscript and address those concerns. Because of the latter, and the enthusiasm of the other original referee, I am going to provisionally accept your paper, even though referee 1 may well think I have made the wrong decision.

> Response: We recognize the valid points brought up by the reviewer. We have attempted to address them as succinctly as possible, within the context of our review. We thank the reviewer for his/her time and yours to help make the manuscript better.

But what does need to be done is make it clear exactly what the ENDH is -- indeed, even the original referee 2 said that it wasn't clear that this really was a hypothesis rather than, say, a methodological approach. I have no problem with it being an approach, but if it is a hypothesis, exactly what is that hypothesis and how could it be falsified? No-one is going to argue against ecological systems being networks in both space and time.

> Response: We clarify our formulation of the Ecological Network Dynamics Hypothesis, now referred to as Ecological Network Dynamics Framework. To do so, we reorganized and rewrote substantial parts of Section 7 now entitled “Ecological Network Dynamics: A Unifying Framework” [Lines 245-334]. Thus, we now no longer rely on a hypothesis to be tested/falsified, using this approach.

Reviewer 1:
As I indicated in my initial review, the idea of better understanding ecological networks by incorporating spatial and temporal dynamics is at the forefront of network ecology. Some of the ideas presented in this manuscript can move the field of network ecology forward.

> Response: Thank you.

Unfortunately, I still do not feel that they are presented in a clear way. First and foremost, is still not clear to me what the "ecological network dynamics hypothesis" is. It is not clearly stated anywhere in the manuscript. As far as I can tell, it is the idea that spatial networks can influence ecological networks and vice versa.

> Response: We clarify our formulation of the Ecological Network Dynamics Hypothesis now referred to as Ecological Network Dynamics Framework. To do so, we reorganized and rewrote substantial parts of Section 7 now entitled "Ecological Network Dynamics: A Unifying Framework" [Lines 245-334]. We believe this has significantly clarified what the framework entails, particularly that the topology of temporal/spatial networks constrain ecological processes in generating species interactions.

In the introduction (lines 41-44) the authors state: "We propose an "ecological network dynamics hypothesis" that explicitly stresses the role of network structure (e.g. numbers and weights of nodes and links) in constraining potential ecological responses in complex ecological systems." To me, this is extremely ambiguous and basically states that network structure matters for how networks respond, which does not seem like a novel insight.

> Response: We reorganized and reworded several parts in Section 7 to indicate that: "Here, we formalize all these previous concepts [28,71] and frameworks [13,66] as the "Ecological Network Dynamics Framework" (hereafter ENDF; Figure 2a) that stresses the set of key network properties that constrain species interaction networks." [Lines 269-271]. Thus, synthetizing and restating the importance of networks in shaping ecological processes.

I feel that the authors need a clear definition/description of the ENDH hypothesis, clear examples of how it would advance network ecology, and a simple schematic figure all in the intro to set the stage for what it is that the authors want to convey to the readers (i.e., what their perspective is). I feel this base information is essential.

> Response: We believe we have cleared up the description and definition of the ENDF, through our reformulation to Section 7 (Ecological Network Dynamics: A Unifying Framework) [Lines 245-334]. Additionally, we have tried to provide more context on this unifying framework via additional examples within this section. We also hope that Figure 2a conveys our perspective of this topic.

As of now, it is a weak/ambiguous introduction followed by a laundry list of network types that are not tied into the main theme of the paper (which is unclear) in any way. The list of network types and brief descriptions and citations of analyses will not be easily accessible to the majority of readers. How these different network types fit into EDNH and how our knowledge of them will be advanced by would be extremely insightful.

> Response: While we recognize that the beginning of the manuscript covers a variety of network techniques, we strongly believe that these are necessary to define and altogether culminate the main thesis of this paper: the ENDF.

I also feel that the paper is still a mix of a methods paper and a perspectives paper that does not achieve much success at either approach. I appreciate that the authors tried to address this issue, but the figures and figure legend are chock-full of jargon and analysis that need more details and

examples or simulations (I agree that this is outside the scope of this paper) and again won't be accessible to readers who are not familiar with network ecology or landscape ecology.

Response: We have removed most aspects related to landscape ecology. We have also removed a figure to have more words to explain better the captions of Figure 2 and 3 [Lines 604-633]. By doing so, we hope that we minimized the jargon and helped to clarify many of the definitions used.

On the other hand, I don't really feel that the "perspective" of the authors is clear enough in this manuscript to move the field forward. I am interested and knowledgeable in both landscape ecology and network ecology and I do not know what to take from this manuscript. I feel like an in-depth methods paper showing simulations and/or a full analysis of an empirical data set would be really good.

Response: We fully recognize the utility of a methods paper in this context. Indeed, a paper going over the pros and cons of particular network/landscape ecological techniques is strongly warranted. However, as this is a review of approach/techniques/ideas of how spatial/temporal networks influence ecological networks and vice-versa, we are not able to perform simulations or analyse empirical data which is beyond the scope of this review.

And a cleaned-up perspectives paper of exactly what EDNH is, how does it differ from trophic metacommunity ecology (sensu Gravel et al. 2011 and Guzman et al. 2019) and what its contributions to both network ecology and landscape ecology are?

Response: We have included these two references in Section 7 and stressed how they convey conceptual similarities with the EDNF [Lines 265-268].