Literature review

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"Mapping biodiversity changes across spatio-temporal scales"

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Outline

Literature review about the link between biodiversity facets trends and spatial/temporal scales.

The idea is to take every paper that talk about biodiversity trends (so far using just the species richness seems already a lot of paper) and to list **1)** which biodiversity metric they use **2)** which taxon/taxa they use, **3)** the spatial scale, **4)** the temporal scale and **5)** what is the dynamic (does the biodiversity metric increase/decrease/doesn't change over time/unclear).

Make a table of all these papers and `group_by(taxa) %>% order_by(spatial_scale | temporal_scale)`. Then see if for each taxa we can find a trend (a bit like in Chase *et al.* 2019 Oikos paper | Jarzyna *et al.* 2015 but here I am not making the analysis, just taking the analysis from papers). Best example found so far: Hill & Hamer 2004

I am using the "Advanced Research" tab of Web of Science which allows me skim through the entire literature using a convenient syntax. For instance:

```
AB = ((biodiversity OR species richness OR diversity) AND
(temporal trend* OR dynamic*) AND
(bird* OR avia*))
```

And

```
AB = ((biodiversity change index)  AND (bird*  OR avia*)  AND trend*)
```

And

```
AB = ((species richness) AND (bird* OR avia*) AND trend*)
```

And

```
ALL=(birds AND species richness AND temporal trend)
```

Dashboard

Reference paper

- 05/07/2021: research wos made with the literature review filter for the first query (stopped at #13) and created the second query (stopped at #2)
- 07/07/2021: questions to Petr: **1)** can the geometric mean of relative abundance + the weighted goodness of fit be used as biodiversity trend index, **2)** can the Farmland Bird Indicator (FBI) be used as biodiversity trend (for me it is more biodiversity health, Chiron et al 2013) **3)** what about the Red List Index trend? **4)** what about Multispecies population indexes?
- 08/07/2021: stopped at the article 41 for research #2.
- 12/08/2021: stopped at article 4 for research #4
- 13/08/2021: stopped at article 8 for research #4
- 17/08/2021: stopped at article 15 for research #4
- 18/08/2021: stopped at article 30 for research #4
- 19/08/2021: stopped at article 46 for research #4
- 20/08/2021: stopped at article 64 for research #4
- 01/09/2021: verifying spatial scales –> stopped at Dittrich 2019
- 02/09/2021: **Question 1:** for the FBI/WBI…*BI indexes, usually they use a GLM/GAM to predict the abundance over the entire spatial extent and then compute the metric. Basically, those metrics are geometric means of predicted species abundances. Which spatial scale to use: the spatial unit of the prediction (i.e. the plot), or the entire area predicted? (Imo, the second option is correct). **Question 2:** same question for the Geometric mean but I am realizing while writing this question that *BI are kind of similar to geometric means so answering the first question will answer this one.

Papers that are driving me mad: Doxa et al., Jiguet et al., and Chiron et al., Eglington and Pearce-Higgins

1. Introduction

Human life quality is intrinsically linked to ecosystems state that he is living in. Indeed, ecosystems services extend in a large spectrum of mechanisms including nutrient cycle, food production, or climate and water cycle regulation (Pereira et al.). Some of those ecosystem functions are managed by bird biodiversity such as seed dispersal, controls pests or pollinate plant. Unfortunately, anthropogenic stressors like habitat loss, over exploitation, pollution or introduction of invasive species could lead biodiversity to its sixth mass extinction (Barnosky et al.).

Biodiversity erosion is now known from everyone and political decisions has been stated in order to limit it (*e.g.* The Convention on Biological Diversity, 2010, 2002). However, these objectives have been so far not reached due mainly to our confusion and misunderstanding about biodiversity dynamic and how to determine it.

As a matter of fact, studying biodiversity can be confusing, especially because several choices must be done. Firstly, the level at which you are looking at the biodiversity must be chosen (*e.g.* species, functional, phylogenetic diversity). Secondly, one must decide which metric is the most appropriate for his study. There are many facets of biodiversity that can be measured by different metrics depending on the objective of your study. Measures of static biodiversity are commonly used such as species richness or α diversity (*i.e.* number of species, Whittaker, b), the Shannon index (Shannon) ,the Simpson index (Simpson) or the Hill number (Hill). The later three biodiversity indexes take into account the relative abundances of the species and can be considered as the *quality* of the biodiversity. On an other hand, the spatial and temporal β diversity will measure the species turnover and can be measured thanks to Whittaker's (Whittaker, a), Sørensen's (Sørensen) or Jaccard's (Jaccard) dissimilarity indexes (*e.g.* Keil et al.).

However, overall biodiversity (*i.e.* taking into account species of every taxa) may not be relevant for one's case study. Thus, several multi-species indicators have also been created, taking into account the abundances of indicator species giving information on the ecosystem health. The most known ones are the Red List Index (Butchart et al., b,a,c) or the Biodiversity Change Index (Normander et al.).

Using all the metrics cited above, we now know that the loss of global biodiversity is unprecedented. However, current scientific literature has also shown that temporal trends in local changes of biodiversity can be opposite to trends at larger scales (*e.g.* Chase et al.). Thus, current changes in biodiversity is far more complex than a simple global decrease: most of the ecosystems undergo alterations of their communities with changes in species composition (Blowes et al.; Dornelas et al.). Wonders persist about how the trend of these different metrics of biodiversity are link to the spatial and temporal scales used when measured.

In order to investigate this link between spatial scales and biodiversity metrics, birds is a relevant taxon. Thanks to the many ornithological monitoring and surveys, we now have a large number of long, high-quality time series on bird populations (Bejček and Stastný). Birds are easy to observe, easy to identify and thus many volunteers are motivated to conduct standardized sampling. Given their ability to change quickly of locations, their presence is also a good indicator for ecosystem health and thus several standardized metrics have been created to assess their populations. For instance, the geometric mean of relative abundances or the goodness-of-fit statistic (Studeny et al., b) are some of the baseline. Other multi-species indicators have also been created specifically for birds, such as the Farmland Bird Indicator (Gregory et al., a), the Forest Bird Indicator (Gregory et al., b) or the Wild Bird Indicator (Gregory and Strien).

Here, I propose to review articles assessing the temporal trends of different avian biodiversity metrics and to look at which spatial scales these studies have been done. Summarizing the trends of these qualitative and/or quantitative avian biodiversity indexes along with their spatial and temporal scales will help to see more clearly how the trends of biodiversity are linked to spatio-temporal scales. It is also important to demonstrate that the information about the sampling plan (*i.e.* spatial scale, time span, temporal scales etc) is not systematically indicated in the scientific literature and can bring confusion to the analysis and comparisons of their trends. I believe that this review can help to have a better overview of the current knowledge on the trend of biodiversity metrics of bird populations.

2. Materials and Methods

For this review, articles of interest were the ones assessing temporal trends of the most common indicators (*i.e.* metrics) of avian biodiversity and specifying spatial and temporal scales. For this, I used the *"advanced search"* tool of the ISI Web of Science Core collection database with these four following queries:

1. `AB = ((biodiversity OR species richness OR diversity) AND (temporal trend* OR dynamic*) AND (bird* OR avia*))` which resulted in 1346 references.

2. `AB = ((biodiversity change index) AND (bird* OR avia*) AND trend*)` which resulted in 60 references.

3. `AB = ((species richness) AND (bird* OR avia*) AND trend*)` which resulted in 313 references.

4. `ALL=(birds AND species richness AND temporal trend)` which resulted in 88 references.

For each query, the title and abstract of the articles were reviewed. When the temporal trend was explicitly specified (either visually or literally), the material and method part was read in order to collect the *spatial grain* of the trend (*i.e.* the area at which the trend is assessed), its *temporal grain* (*i.e.* the time span at which data have been gathered on the field), the *spatial extent* (*i.e.* the entire area at which the study applies), the *temporal extent* and the *beginning and ending years* of the study as well as the *general trend* of the metric (Tab. 2.1).

Concerning the trend assessment, some papers contained the *p-value* or directly specified the significant trend of the metric. However, a portion of papers gives only visual representations of the trend. For those, the standard error was used when displayed. For the very few only giving the trend, the rule of thumb was applied. Information can be found in the column *Note* of the Tab. 2.2 of the supplementary material. Moreover, the final trend retained (*i.e.* either *Increase*, *Stable* or *Decrease*) doesn't reflect all the fluctuations of the metric through time but rather the difference between the starting and ending points.

Moreover, Pilotto et al. conducted a meta-analysis in which they computed and summarized the trend of four biodiversity metrics (namely, species richness, species diversity, abundance and temporal turnover). Some of them were concerning bird communities. For those latter, I used their code and data on the github repository of their paper in order to compute the trends of these four metrics for the bird datasets.

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness,

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Harrison et al. (a)	Abundance	1.0000e+04	1.0	200000	18	1994-2011	Great Britain, UK	Increase
	Abundance	1.0000e+04	1.0	200000	18	1994-2011	Great Britain, UK	Stable
	Abundance	1.0000e+04	1.0	200000	18	1994-2011	Great Britain, UK	Stable
Pilotto et al.	SR	NA	NA	10180000	NA	NA	Europe	Increase
	Simpson	NA	NA	10180000	NA	NA	Europe	Increase
	Abundance	NA	NA	10180000	NA	NA	Europe	Stable
	Temporal beta-diversity	NA	NA	10180000	NA	NA	Europe	Stable
Barnagaud et al.	SR	2.5000e+01	1.0	9834000	41	1970-2011	USA	Increase
	Abundance	2.5000e+01	1.0	9834000	41	1970-2011	USA	Decrease
	Evenness	2.5000e+01	1.0	9834000	41	1970-2011	USA	Increase
	Functional richness	2.5000e+01	1.0	9834000	41	1970-2011	USA	Increase
	Functional dispersion	2.5000e+01	1.0	9834000	41	1970-2011	USA	Stable
	Functional evenness	2.5000e+01	1.0	9834000	41	1970-2011	USA	Increase
Reif et al.	SR	2.5000e+00	1.0	79000	23	1982-2004	Czech Rep.	Stable
	SR	7.9000e+04	1.0	79000	23	1982-2004	Czech Rep.	Stable

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
	Spatial beta-diversity	2.5000e+00	1.0	79000	23	1982-2004	Czech Rep.	Stable
	CSI	7.9000e+04	1.0	79000	23	1982-2004	Czech Rep.	Decrease
Schipper et al.	Abundance	2.5000e+01	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	SR	2.5000e+01	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Diversity	2.5000e+01	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Diversity	2.5000e+01	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Functional richness	2.5000e+01	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Functional evenness	2.5000e+01	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Functional diversity	2.5000e+01	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Decrease
Sorte and Boecklen	SR	2.5000e+01	1.0	9834000	36	1968-2003	USA	Increase
	Abundance	2.5000e+01	1.0	9834000	36	1968-2003	USA	Decrease
	Diversity	2.5000e+01	1.0	9834000	36	1968-2003	USA	Decrease

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Wretenberg et al.	SR	NA	1.0	1800	11	1994-2004	Sweden	Decrease
Ram et al.	SR	NA	1.0	350000	18	1998-2015	Sweden	Increase
	Abundance	1.6000e+00	1.0	350000	18	1998-2015	Sweden	Increase
Harrison et al. (b)	Abundance	1.0000e+04	0.5	NA	20	1994-2013	UK	Increase
	Abundance	1.0000e+04	0.5	NA	20	1994-2013	UK	Stable
	Abundance	1.0000e+04	0.5	NA	20	1994-2013	UK	Stable
Jarzyna and Jetz	SR	2.5000e+03	1.0	9834000	45	1969-2013	USA	Increase
	SR	4.0000e+04	1.0	9834000	45	1969-2013	USA	Increase
	SR	6.4000e+05	1.0	9834000	45	1969-2013	USA	Increase
	SR	9.8340e+06	1.0	9834000	45	1969-2013	USA	Increase
	SR	1.4894e+08	1.0	148940000	45	1969-2013	Wolrd	Decrease
	Temporal beta-diversity	2.5000e+03	1.0	9834000	45	1969-2013	USA	Increase
	Temporal beta-diversity	4.0000e+04	1.0	9834000	45	1969-2013	USA	Increase
	Temporal beta-diversity	6.4000e+05	1.0	9834000	45	1969-2013	USA	Increase
	Temporal beta-diversity	9.8340e+06	1.0	9834000	45	1969-2013	USA	Increase

Table 2.1: SR = species richness, Ab = abundance, Eve = evenness, *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
	Temporal beta-diversity	1.4894e+08	1.0	148940000	45	1969-2013	Wolrd	Stable

Supplementary materials

Table 2.2: Supplementary informations on each trend

Reference	Metric	Spatial grain (Km^2)	Trend	Note
Harrison et al. (a)	Abundance	10000	Increase	To assess the metric, they use a GAM to predict the abundance over the entire area of interest (spatial resolution = 1 Km^2) and then compute the geometric mean of species abundance = Multi Species Index (as in Studeny et al. (a)) from the prediction. Data used to learn the GAM are sampled from plots of 1 Km^2. Farmland communities
Harrison et al. (a)	Abundance	10000	Stable	Farmland communities, GoF (λ = -1) = weighted towards the rare species
Harrison et al. (a)	Abundance	10000	Stable	Farmland communities, GoF (λ = -2) weighted towards the common species
Pilotto et al.	SR	Local	Increase	”Analyses of the trends in local biodiversity over large spatial scales”
Pilotto et al.	Simpson	Local	Increase	”Analyses of the trends in local biodiversity over large spatial scales”
Pilotto et al.	Abundance	Local	Stable	”Analyses of the trends in local biodiversity over large spatial scales”
Pilotto et al.	Temporal beta-diversity	Local	Stable	”Analyses of the trends in local biodiversity over large spatial scales”
Barnagaud et al.	SR	25	Increase	They model the trend of the metrics using GAMM at the road scales. Area of the road = (40/0.8)*(pi*4002) with a road of 40 Km with point counts spaced by 0.8 Km and a census radius of 400m
Barnagaud et al.	Abundance	25	Decrease	NA
Barnagaud et al.	Evenness	25	Increase	NA
Barnagaud et al.	Functional richness	25	Increase	NA
Barnagaud et al.	Functional dispersion	25	Stable	NA
Barnagaud et al.	Functional evenness	25	Increase	NA
Reif et al.	SR	2.5	Stable	JPSP data, transect scale
Reif et al.	SR	79000	Stable	JPSP data, national scale
Reif et al.	Spatial beta-diversity	2.5	Stable	Jaccard index, pairwise comparisions between transects

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km²)	Trend	Note
Reif et al.	CSI	79000	Decrease	Metric = Community Specialization Index, i.e. functional diveristy index
Schipper et al.	Abundance	25	Increase	The metric (i.e. geometric mean) is meaned over each road. Area of the road = 50*(pi*4002) with 50 census point per road and a census radius of 400m
Schipper et al.	SR	25	Increase	NA
Schipper et al.	Diversity	25	Increase	Metric = Shannon
Schipper et al.	Diversity	25	Increase	Metric = Simpson
Schipper et al.	Functional richness	25	Increase	NA
Schipper et al.	Functional evenness	25	Increase	NA
Schipper et al.	Functional diversity	25	Decrease	NA
Sorte and Boecklen	SR	25	Increase	The metric is meaned over each road. Area of the road = 50*(pi*4002) with 50 census point per road and a census radius of 400m
Sorte and Boecklen	Abundance	25	Decrease	NA
Sorte and Boecklen	Diversity	25	Decrease	Metric = evenness
Wretenberg et al.	SR	0,03	Decrease	looking at the trend through different environmental policies, " local species richness (i.e. at the scale of sites = 3 hectares) decreased significantly probably as a result of an overall reduced abundance of several species. "
Ram et al.	SR	3,2	Increase	SR for forest species meaned over roads, spatial grain = 8* .4 with road of 8 Km and census radius no limitations so assumed 200m
Ram et al.	Abundance	1.6	Increase	MSI for forest species, road of 8 Km with no limitations so assumed 200m
Harrison et al. (b)	Abundance	10000	Increase	Geomteric mean of species abundance, they predict the abundance with resolution of 1 Km² and then computed the metric for each 10000 Km² cell across Great Britain, Visited twice a year

Table 2.2: Supplementary informations on each trend *(continued)*

Reference	Metric	Spatial grain (Km²)	Trend	Note
Harrison et al. (b)	Abundance	10000	Stable	GoF (λ = -1) = toward rare species" The goodness-of-fit-based measure of biodiversity suggests that both rare and common species made gains through much of Britain in the first half of the time period, and losses in the second half.", Visited twice a year / Increase first half and second second halfGoF (λ = -1)
Harrison et al. (b)	Abundance	10000	Stable	GoF (λ = -2) = toward common species " The goodness-of-fit-based measure of biodiversity suggests that both rare and common species made gains through much of Britain in the first half of the time period, and losses in the second half.", Visited twice a year / Increase first half and second second half
Jarzyna and Jetz	SR	2500	Increase	NA
Jarzyna and Jetz	SR	40000	Increase	NA
Jarzyna and Jetz	SR	640000	Increase	NA
Jarzyna and Jetz	SR	9834000	Increase	NA
Jarzyna and Jetz	SR	148940000	Decrease	NA
Jarzyna and Jetz	Temporal beta-diversity	2500	Increase	NA
Jarzyna and Jetz	Temporal beta-diversity	40000	Increase	NA
Jarzyna and Jetz	Temporal beta-diversity	640000	Increase	NA
Jarzyna and Jetz	Temporal beta-diversity	9834000	Increase	NA
Jarzyna and Jetz	Temporal beta-diversity	148940000	Stable	NA

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