Literature review

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"Mapping biodiversity changes across spatio-temporal scales"

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Contents

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

Meeting with Petr

1) How is the trend of biodiversity metrics linked to spatial grain/spatial extent and temporal grain/temporal extent.

- Talk about papers which does compare (Jarzyna Jetz)
- The inconsistency of reporting scales (especially for models as in Jiguet et al.or Chiron et al., and for MSI metrics)

2) Data heterogeneity

- Lack of spatial replication. That's why this review is important
- The inconsistency of reporting scales (especially for models, and for MSI metrics)
- Lack in other than western countries
- Metric heterogeneity (Freixedas 2001 but they don't mention the macroecological ones as McGill, my struggle because of the time for space substitution as Hill & Hammer). Some metrics takes into account temporal dynamic but some papers don't look at the trend of these metrics (Jarzyna et al. 2015)

- Can we use space for time substitution as an actual substitution (Hill & Hammer)

- Pop trends are usually stronger (cf. all the abundance metrics)

3) Future directions

- Lack of data for other thsn western cvountries: important to harvest data in other countries

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.

specify that it is mainly for continental/coastal birds but no look at islandic communities

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. 3.1).

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. 3.2 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.

3. Results

- First of all: there was 9 *Decrease*, 31 *Increase* and 14 *Stable* computed trends across the literature.
- For each metric, the proportion of trend directions are:

rownames	Decrease	Increase	Stable	n
Abundance	0.3333333	0.2666667	0.4000000	15
Diversity	0.0000000	1.0000000	0.0000000	2
Evenness	0.3333333	0.6666667	0.0000000	3
Functional diversity	1.0000000	0.0000000	0.0000000	1
Functional evenness	0.0000000	1.0000000	0.0000000	1
Functional richness	0.0000000	1.0000000	0.0000000	1
Simpson	0.0000000	1.0000000	0.0000000	2
Spatial beta-diversity	0.0000000	0.0000000	1.0000000	1
SR	0.0909091	0.6818182	0.2272727	22
Temporal beta-diversity	0.0000000	0.6666667	0.3333333	6

Table 3.1: Trends of different metrics of biodiversity at various spatial and temporal scales

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
Harrison et al. (a)	Abundance	10000	1.0	200000	18	1994-2011	Great Britain, UK	Increase
	Abundance	10000	1.0	200000	18	1994-2011	Great Britain, UK	Stable
	Abundance	10000	1.0	200000	18	1994-2011	Great Britain, UK	Stable
Pilotto et al.	SR	Local	NA	10180000	NA	NA	Europe	Increase
	Simpson	Local	NA	10180000	NA	NA	Europe	Increase
	Abundance	Local	NA	10180000	NA	NA	Europe	Stable
	Temporal beta-diversity	Local	NA	10180000	NA	NA	Europe	Stable
Barnagaud et al.	SR	25	1.0	9834000	41	1970-2011	USA	Increase
	Evenness	25	1.0	9834000	41	1970-2011	USA	Increase
Reif et al.	SR	2.5	1.0	79000	23	1982-2004	Czech Rep.	Stable
	SR	79000	1.0	79000	23	1982-2004	Czech Rep.	Stable
	Spatial beta-diversity	2.5	1.0	79000	23	1982-2004	Czech Rep.	Stable
Schipper et al.	Abundance	25	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	SR	25	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Diversity	25	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase

Table 3.1: Trends of different metrics of biodiversity at various spatial and temporal scales *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
	Diversity	25	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Functional richness	25	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Functional evenness	25	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Increase
	Functional diversity	25	5.0	24710000	40	1971-2010	Canada, USA, Mexico	Decrease
Sorte and Boecklen	SR	25	1.0	9834000	36	1968-2003	USA	Increase
	Abundance	25	1.0	9834000	36	1968-2003	USA	Decrease
	Evenness	25	1.0	9834000	36	-	USA	Decrease
Wretenberg et al.	SR	0,03	1.0	1800	11	1994-2004	Sweden	Decrease
Ram et al.	SR	3,2	1.0	350000	18	1998-2015	Sweden	Increase
	Abundance	1.6	1.0	350000	18	1998-2015	Sweden	Increase
Harrison et al. (b)	Abundance	10000	0.5	NA	20	1994-2013	UK	Increase
	Abundance	10000	0.5	NA	20	1994-2013	UK	Stable
	Abundance	10000	0.5	NA	20	1994-2013	UK	Stable
Jarzyna and Jetz	SR	2500	1.0	9834000	45	1969-2013	USA	Increase
	SR	40000	1.0	9834000	45	1969-2013	USA	Increase

Table 3.1: Trends of different metrics of biodiversity at various spatial and temporal scales *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
	SR	640000	1.0	9834000	45	1969-2013	USA	Increase
	SR	9834000	1.0	9834000	45	1969-2013	USA	Increase
	SR	148940000	1.0	148940000	45	1969-2013	World	Decrease
	Temporal beta-diversity	2500	1.0	9834000	45	1969-2013	USA	Increase
	Temporal beta-diversity	40000	1.0	9834000	45	1969-2013	USA	Increase
	Temporal beta-diversity	640000	1.0	9834000	45	1969-2013	USA	Increase
	Temporal beta-diversity	9834000	1.0	9834000	45	1969-2013	USA	Increase
	Temporal beta-diversity	148940000	1.0	148940000	45	1969-2013	World	Stable
Davey et al.	Simpson	1	1.0	242495	13	1994-2006	UK	Increase
	SR	1	1.0	242495	13	1994-2006	UK	Increase
	Evenness	1	1.0	242495	13	1994-2006	UK	Increase
Chiron et al.	Abundance	Admin. unit	1.0	643801	14	2007-2020	France	Decrease
	Abundance	Admin. unit	1.0	643801	14	2007-2020	France	Decrease
	Abundance	Admin. unit	1.0	643801	14	2007-2020	France	Decrease
	Abundance	Admin. unit	1.0	643801	14	2007-2020	France	Decrease
Van Turnhout et al.	SR	Admin. unit	4.0	41543	28	1973-2000	Netherlands	Increase

Table 3.1: Trends of different metrics of biodiversity at various spatial and temporal scales *(continued)*

Reference	Metric	Spatial grain (Km²)	Temporal grain (year)	Spatial extent (Km²)	Temporal extent (year)	Years	Country	Trend
	SR	25	4.0	41543	28	1973-2000	Netherlands	Increase
	SR	41543	4.0	41543	28	1973-2000	Netherlands	Increase
Chase et al.	SR	150	5.0	2800000	30	1982–2011	USA, Canada	Stable
	SR	400	5.0	2800000	30	1982–2011	USA, Canada	Stable
	SR	800	5.0	2800000	30	1982–2011	USA, Canada	Stable
	SR	1350	5.0	2800000	30	1982–2011	USA, Canada	Increase
	SR	11000	5.0	2800000	30	1982–2011	USA, Canada	Increase
Bowler et al.	Abundance	National unit	1.0	520475	27	1990-2016	Czech Rep., Switzerland, Denmark, Germany	Stable

Supplementary materials

Table 3.2: Supplementary informations about each article

Reference	Spatial grain (Km^2)	Trend	Note
Harrison et al. (a)	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
	10000	Stable	Farmland communities, GoF (λ = -1) = weighted towards the rare species
	10000	Stable	Farmland communities, GoF (λ = -2) weighted towards the common species
Pilotto et al.	Local	Increase	”Analyses of the trends in local biodiversity over large spatial scales”
	Local	Increase	”Analyses of the trends in local biodiversity over large spatial scales”
	Local	Stable	”Analyses of the trends in local biodiversity over large spatial scales”
	Local	Stable	”Analyses of the trends in local biodiversity over large spatial scales”
Barnagaud et al.	25	Increase	Mean change of SR 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
	25	Increase	Not sure that it is at the road scale: ”Taxonomic evenness showed a marginal, yet significant, non-linear increase from close to 0.54 in the first decade to 0.56 in the last decade (Table 1), suggesting a light trend towards a more even distribution of species' abundances among species within local assemblages ”
Reif et al.	2.5	Stable	JPSP data, transect scale
	79000	Stable	JPSP data, national scale
	2.5	Stable	Jaccard index, pairwise comparisions between transects
Schipper et al.	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
	25	Increase	NA
	25	Increase	Metric = Shannon

Table 3.2: Supplementary informations about each article *(continued)*

Reference	Spatial grain (Km²)	Trend	Note
	25	Increase	Metric = Simpson
	25	Increase	NA
	25	Increase	NA
	25	Decrease	NA
Sorte and Boecklen	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
	25	Decrease	NA
	25	Decrease	Metric = evenness
Wretenberg et al.	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.	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
	1.6	Increase	MSI for forest species, road of 8 Km with no limitations so assumed 200m
Harrison et al. (b)	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
	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)
	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

Table 3.2: Supplementary informations about each article *(continued)*

Reference	Spatial grain (Km^2)	Trend	Note
Jarzyna and Jetz	2500	Increase	NA
	40000	Increase	NA
	640000	Increase	NA
	9834000	Increase	NA
	148940000	Decrease	NA
	2500	Increase	NA
	40000	Increase	NA
	640000	Increase	NA
	9834000	Increase	NA
	148940000	Stable	NA
Davey et al.	1	Increase	They predict the metric using a GAM with spatial resolution of 1 Km^2. Then they show the trend for the mean value of the metric per year
	1	Increase	NA
	1	Increase	NA
Chiron et al.	Admin. unit	Decrease	Concerning the spatial scale, predictions are made using the spatial unit of 4 Km^2 and the FBI is computed for each region of France, then meanned. Prediction with baseline scenario
	Admin. unit	Decrease	FBI prediction with CAP greening cenario
	Admin. unit	Decrease	FBI prediction with No Pillar I scenario
	Admin. unit	Decrease	FBI prediction with biofuel scenario
Van Turnhout et al.	Admin. unit	Increase	For each region, the trend is computed
	25	Increase	Mainly increase of SR but the proportion of negative trend were higher than for the regional scale

Table 3.2: Supplementary informations about each article *(continued)*

Reference	Spatial grain (Km²)	Trend	Note
	41543	Increase	National scale
Chase et al.	150	Stable	NA
	400	Stable	NA
	800	Stable	NA
	1350	Increase	NA
	11000	Increase	NA
Bowler et al.	National unit	Stable	Metric = MSI, as many and as intense increase (i.e. Czech Rep. and Switzerland) than decrease (i.e. Germany and Denmarl)

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