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

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

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.) 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	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Barnagaud et al.	SR	0.5 Km^2	1 year	9,834 millions km^2	41 years	1970-2011	USA	Increase
Barnagaud et al.	Abundance	0.5 Km^2	1 year	9,834 millions km^2	41 years	1970-2011	USA	Decrease
Barnagaud et al.	Evenness	0.5 Km^2	1 year	9,834 millions km^2	41 years	1970-2011	USA	Increase
Barnagaud et al.	Functional richness	0.5 Km^2	1 year	9,834 millions km^2	41 years	1970-2011	USA	Increase
Barnagaud et al.	Functional dispersion	0.5 Km^2	1 year	9,834 millions km^2	41 years	1970-2011	USA	Stable
Barnagaud et al.	Functional evenness	0.5 Km^2	1 year	9,834 millions km^2	41 years	1970-2011	USA	Increase
Roels et al.	SR	0.04 Km^2	1 year	0.04 Km^2	5 years	NA	Panama	Increase
Roels et al.	Bird activity	0.04 Km^2	1 year	0.04 Km^2	5 years	NA	Panama	Increase
Wretenberg et al.	SR	0.03 Km^2	1 year	1800 km2	11 years	1994-2004	Sweden	Decrease
Ram et al.	SR	1.6 Km^2	1 year	350 000 Km2	18 years	1998-2015	Sweden	Increase
Ram et al.	SR	1.6 Km^2	1 year	350 000 Km2	18 years	1998-2015	Sweden	Stable
Ram et al.	SR	1.6 Km^2	1 year	350 000 Km2	18 years	1998-2015	Sweden	Increase
Ram et al.	Multi-species indicator	1.6 Km^2	1 year	350 000 Km2	18 years	1998-2015	Sweden	Increase
Ram et al.	Multi-species indicator	1.6 Km^2	1 year	350 000 Km2	18 years	1998-2015	Sweden	Increase

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Harrison et al. (b)	Geometric mean	10 000 Km^2	0.5 year	242 495 km^2	20 years	1994-2013	UK	Increase
Harrison et al. (b)	GoF (λ = -1)	10 000 Km^2	0.5 year	242 495 km^2	20 years	1994-2013	UK	Stable
Harrison et al. (b)	GoF (λ = -2)	10 000 Km^2	0.5 year	242 495 km^2	20 years	1994-2013	UK	Stable
Doxa et al.	FBI	4 Km^2	1 year	643 801 km^2	8 years	2001-2008	France	Increase
Doxa et al.	FBI	4 Km^2	1 year	643 801 km^2	8 years	2001-2008	France	Stable
Doxa et al.	FBI	4 Km^2	1 year	643 801 km^2	8 years	2001-2008	France	Stable
Arnold et al.	SR	0.02 Km^2	1 year	1000 km^2	100 years	NA	Trinidad	Stable
Arnold et al.	Shannon	0.02 Km^2	1 year	1000 km^2	100 years	NA	Trinidad	Stable
Arnold et al.	Simpson	0.02 Km^2	1 year	1000 km^2	100 years	NA	Trinidad	Stable
Xu et al.	SR	6.56 Km^2	1 year	6.56 Km^2	12 years	2002-2013	China	Decrease
Jiguet et al.	GBI	4 Km^2	1 year	643 801 km^2	22 years	1989-2009	France	Increase
Jiguet et al.	WBI	4 Km^2	1 year	643 801 km^2	22 years	1989-2009	France	Increase
Jiguet et al.	UBI	4 Km^2	1 year	643 801 km^2	22 years	1989-2009	France	Increase
Jiguet et al.	FBI	4 Km^2	1 year	643 801 km^2	22 years	1989-2009	France	Increase
Jiguet et al.	EU bird directive	4 Km^2	1 year	643 801 km^2	22 years	1989-2009	France	Increase
Jiguet et al.	RLI (Red list Index)	NA	1 year	10 180 000 km^2	22 years	1989-2009	France	Decrease
Keten	SR	1.7 Km^2	1 year	1.7 Km^2	11 years	2006-2016	Turkey	Stable

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Davey et al.	Simpson	1 km^2	1 year	242 495 km^2	13 years	1994-2006	UK	Increase
Davey et al.	SR	1 km^2	1 year	242 495 km^2	13 years	1994-2006	UK	Increase
Davey et al.	Evenness	1 km^2	1 year	242 495 km^2	13 years	1994-2006	UK	Increase
Christian et al.	SR	15.4 Km^2	NA	15.4 km2	209 ans	1898-2006	France	Increase
Dittrich et al.	SR	0.053 km^2	0.33 year	53 Km^2	3 years	2010-2012	Spain	Increase
Dittrich et al.	SR	0.053 km^2	1 year	53 Km^2	3 years	2010-2012	Spain	Increase
Dittrich et al.	SR	0.083 km^2	0.33 year	53 Km^2	3 years	2012-2014	UK	Stable
Dittrich et al.	SR	0.083 km^2	1 year	53 Km^2	3 years	2012-2014	UK	Stable
Sirami and Monadjem	SR	0.38 km^2	1 year	430 Km^2	21 years	1998-2018	Swaziland	Decrease
García-Navas et al.	spatial beta-diversity	267 Km^2	1 year	267 Km^2	20 years	1999-2018	Switzerland	Decrease
McGeoch et al.	RLI (Red list Index)	NA	1 year	148,939,063.133 km^2	11 years	1998-2008	Worldwide	Decrease
Ellis et al.	SR	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Stable
Ellis et al.	SR	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Stable
Ellis et al.	SR	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Increase
Ellis et al.	SR	0.48 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Stable
Ellis et al.	Shannon	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Increase
Ellis et al.	Shannon	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Decrease
Ellis et al.	Shannon	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Increase
Ellis et al.	Shannon	0.48 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Increase

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Ellis et al.	Simpson	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Increase
Ellis et al.	Simpson	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Decrease
Ellis et al.	Simpson	0.16 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Increase
Ellis et al.	Simpson	0.48 Km^2	1 year	NA	21 years	1994-2014	Oregon, USA	Decrease
Sicurella et al.	Occurence (%)	17 370.3 Km^2	1 year	23 844 km^2	22 years	1992-2013	Lombardy, Italy	Stable
Sicurella et al.	Occurence (%)	1 403.9 Km^2	1 year	23 844 km^2	22 years	1992-2013	Lombardy, Italy	Stable
Sicurella et al.	Occurence (%)	6 461.9 Km^2	1 year	23 844 km^2	22 years	1992-2013	Lombardy, Italy	Increase
Nally	SR	0.49 Km^2	1 day	10 Km^2	3 years	1994-1996	Australia	Increase
Latta et al.	SR	0.000942 Km^2	2 years	NA	14 years	1994-2007	Ecuador	Decrease
Latta et al.	SR	0.000942 Km^2	2 years	NA	14 years	1994-2007	Ecuador	Decrease
Scarton	SR	0.55 Km^2	2 years	0.55 Km^2	25 years	1990-2014	Lagoon of Venice, Italy	Increase
Scarton	Shannon	0.55 Km^2	2 years	0.55 Km^2	25 years	1990-2014	Lagoon of Venice, Italy	Increase
Scarton	Temporal beta-diversity	0.55 Km^2	2 years	0.55 Km^2	25 years	1990-2014	Lagoon of Venice, Italy	Increase
Scarton	Temporal beta-diversity	0.55 Km^2	2 years	0.55 Km^2	25 years	1990-2014	Lagoon of Venice, Italy	Increase
Chiron et al.	FBI	4 Km^2	1 year	643 801 Km^2	14 years	2007-2020	France	Decrease
Chiron et al.	FBI	4 Km^2	1 year	643 801 Km^2	14 years	2007-2020	France	Decrease
Chiron et al.	FBI	4 Km^2	1 year	643 801 Km^2	14 years	2007-2020	France	Decrease
Chiron et al.	FBI	4 Km^2	1 year	643 801 Km^2	14 years	2007-2020	France	Decrease

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Eglington and Pearce-Higgins	FBI	1 Km^2	1 year	242 495 km^2	39 years	1970-2008	UK	Decrease
Harrison et al. (a)	Geometric mean	10 000 Km^2	1 year	200 000 km^2	18 years	1994-2011	Great Britain, UK	Stable
Harrison et al. (a)	GoF (λ = -1)	10 000 Km^2	1 year	200 000 km^2	18 years	1994-2011	Great Britain, UK	Decrease
Harrison et al. (a)	GoF (λ = -2)	10 000 Km^2	1 year	200 000 km^2	18 years	1994-2011	Great Britain, UK	Increase
Harrison et al. (a)	Geometric mean	62 000 Km^2	1 year	77 933 Km^2	18 years	1994-2011	Scotland, UK	Increase
Harrison et al. (a)	GoF (λ = -1)	62 000 Km^2	1 year	77 933 Km^2	18 years	1994-2011	Scotland, UK	Stable
Harrison et al. (a)	GoF (λ = -2)	62 000 Km^2	1 year	77 933 Km^2	18 years	1994-2011	Scotland, UK	Increase
Harrison et al. (a)	Geometric mean	16 000 Km^2	1 year	20,779 Km^2	18 years	1994-2011	Wales, UK	Stable
Harrison et al. (a)	GoF (λ = -1)	16 000 Km^2	1 year	20,779 Km^2	18 years	1994-2011	Wales, UK	Stable
Harrison et al. (a)	GoF (λ = -2)	16 000 Km^2	1 year	20,779 Km^2	18 years	1994-2011	Wales, UK	Stable
Harrison et al. (a)	Geometric mean	130 000 Km^2	1 year	130 279 Km^2	18 years	1994-2011	England, UK	Decrease

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Harrison et al. (a)	GoF (λ = -1)	131 000 Km^2	1 year	130 279 Km^2	18 years	1994-2011	England, UK	Decrease
Harrison et al. (a)	GoF (λ = -2)	132 000 Km^2	1 year	130 279 Km^2	18 years	1994-2011	England, UK	Stable
Harrison et al. (a)	Geometric mean	10 000 Km^2	1 year	200 000 km^2	18 years	1994-2011	Great Britain, UK	Increase
Harrison et al. (a)	GoF (λ = -1)	10 000 Km^2	1 year	200 000 km^2	18 years	1994-2011	Great Britain, UK	Stable
Harrison et al. (a)	GoF (λ = -2)	10 000 Km^2	1 year	200 000 km^2	18 years	1994-2011	Great Britain, UK	Decrease
Harrison et al. (a)	Geometric mean	14 000 Km^2	1 year	77 933 Km^2	18 years	1994-2011	Scotland, UK	Increase
Harrison et al. (a)	GoF (λ = -1)	14 000 Km^2	1 year	77 933 Km^2	18 years	1994-2011	Scotland, UK	Increase
Harrison et al. (a)	GoF (λ = -2)	14 000 Km^2	1 year	77 933 Km^2	18 years	1994-2011	Scotland, UK	Stable
Harrison et al. (a)	Geometric mean	32 300 Km^2	1 year	130 279 Km^2	18 years	1994-2011	England, UK	Increase
Harrison et al. (a)	GoF (λ = -1)	32 300 Km^2	1 year	130 279 Km^2	18 years	1994-2011	England, UK	Decrease
Harrison et al. (a)	GoF (λ = -2)	32 300 Km^2	1 year	130 279 Km^2	18 years	1994-2011	England, UK	Stable

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Harrison et al. (a)	Geometric mean	3 116 Km^2	1 year	20,779 Km^2	18 years	1994-2011	Wales, UK	Stable
Harrison et al. (a)	GoF (λ = -1)	3 116 Km^2	1 year	20,779 Km^2	18 years	1994-2011	Wales, UK	Stable
Harrison et al. (a)	GoF (λ = -2)	3 116 Km^2	1 year	20,779 Km^2	18 years	1994-2011	Wales, UK	Increase
Juslén et al.	RLI (Red list Index)	338 440 km^2	1 year	338 440 km^2	10 years	2001-2010	Finland	Decrease
Normander et al.	BCI (Biodviersity Change Index)	84 266 km^2	NA	1 260 663 km^2	16 years	1990-2005	Finland, Sweden, Norway, Denmark and Iceland	Decrease
Normander et al.	BCI (Biodviersity Change Index)	529 831 km^2	NA	1 260 663 km^2	16 years	1990-2005	Finland, Sweden, Norway, Denmark and Iceland	Stable
Normander et al.	BCI (Biodviersity Change Index)	163 131 km^2	NA	1 260 663 km^2	16 years	1990-2005	Finland, Sweden, Norway, Denmark and Iceland	Decrease

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Schipper et al.	Geometric mean	32 Km^2	5 years	21 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Geometric mean	32 Km^2	5 years	21 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Geometric mean	32 Km^2	5 years	21 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Geometric mean	32 Km^2	5 years	22 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Geometric mean	32 Km^2	5 years	23 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Stable
Schipper et al.	SR	32 Km^2	5 years	24 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	SR	32 Km^2	5 years	25 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	SR	32 Km^2	5 years	26 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	SR	32 Km^2	5 years	27 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	SR	32 Km^2	5 years	28 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Stable
Schipper et al.	Shannon	32 Km^2	5 years	29 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Schipper et al.	Shannon	32 Km^2	5 years	30 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Shannon	32 Km^2	5 years	31 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Shannon	32 Km^2	5 years	32 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Shannon	32 Km^2	5 years	33 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Simpson	32 Km^2	5 years	34 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Simpson	32 Km^2	5 years	35 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Stable
Schipper et al.	Simpson	32 Km^2	5 years	36 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Simpson	32 Km^2	5 years	37 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Simpson	32 Km^2	5 years	38 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional richness	32 Km^2	5 years	39 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional richness	32 Km^2	5 years	40 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Schipper et al.	Functional richness	32 Km^2	5 years	41 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional richness	32 Km^2	5 years	42 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional richness	32 Km^2	5 years	43 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Functional evenness	32 Km^2	5 years	44 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional evenness	32 Km^2	5 years	45 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional evenness	32 Km^2	5 years	46 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Functional evenness	32 Km^2	5 years	47 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional evenness	32 Km^2	5 years	48 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional divergence	32 Km^2	5 years	49 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Functional divergence	32 Km^2	5 years	50 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional divergence	32 Km^2	5 years	51 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Schipper et al.	Functional divergence	32 Km^2	5 years	52 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Functional divergence	32 Km^2	5 years	53 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Schipper et al.	Functional dispersion	32 Km^2	5 years	54 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional dispersion	32 Km^2	5 years	55 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional dispersion	32 Km^2	5 years	56 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional dispersion	32 Km^2	5 years	57 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Increase
Schipper et al.	Functional dispersion	32 Km^2	5 years	58 792 000 km^2	40 years	1971-2010	Canada, USA, Mexico	Decrease
Pilotto et al.	SR	1402 Km^2	0.08 year	1402 Km^2	27 years	1991-2017	Belgium	Decrease
Pilotto et al.	Simpson	1402 Km^2	0.08 year	1402 Km^2	27 years	1991-2017	Belgium	Increase
Pilotto et al.	Abundance	1402 Km^2	0.08 year	1402 Km^2	27 years	1991-2017	Belgium	Decrease
Pilotto et al.	Temporal beta-diversity	1402 Km^2	0.08 year	1402 Km^2	27 years	1991-2017	Belgium	Stable
Pilotto et al.	SR	509 Km^2	1 year	509 Km^2	42 years	1976-2017	Bulgaria	Increase
Pilotto et al.	Simpson	509 Km^2	1 year	509 Km^2	42 years	1976-2017	Bulgaria	Stable
Pilotto et al.	Abundance	509 Km^2	1 year	509 Km^2	42 years	1976-2017	Bulgaria	Increase

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Pilotto et al.	Temporal beta-diversity	509 Km^2	1 year	509 Km^2	42 years	1976-2017	Bulgaria	Decrease
Pilotto et al.	SR	10 Km^2	1 year	10 Km^2	42 years	1976-2017	Bulgaria	Increase
Pilotto et al.	Simpson	10 Km^2	1 year	10 Km^2	42 years	1976-2017	Bulgaria	Stable
Pilotto et al.	Abundance	10 Km^2	1 year	10 Km^2	42 years	1976-2017	Bulgaria	Stable
Pilotto et al.	Temporal beta-diversity	10 Km^2	1 year	10 Km^2	42 years	1976-2017	Bulgaria	Stable
Pilotto et al.	SR	9.02 Km^2	1 year	9.02 Km^2	41 years	1977-2017	Bulgaria	Increase
Pilotto et al.	Simpson	9.02 Km^2	1 year	9.02 Km^2	41 years	1977-2017	Bulgaria	Increase
Pilotto et al.	Abundance	9.02 Km^2	1 year	9.02 Km^2	41 years	1977-2017	Bulgaria	Stable
Pilotto et al.	Temporal beta-diversity	9.02 Km^2	1 year	9.02 Km^2	41 years	1977-2017	Bulgaria	Stable
Pilotto et al.	SR	32 Km^2	1 year	32 Km^2	55 years	1961-2015	Spain	Increase
Pilotto et al.	Simpson	32 Km^2	1 year	32 Km^2	55 years	1961-2015	Spain	Increase
Pilotto et al.	Abundance	32 Km^2	1 year	32 Km^2	55 years	1961-2015	Spain	Increase
Pilotto et al.	Temporal beta-diversity	32 Km^2	1 year	32 Km^2	55 years	1961-2015	Spain	Decrease
Pilotto et al.	SR	52 000 Km^2	1 year	52 000 Km^2	55 years	1961-2015	France	Stable
Pilotto et al.	Simpson	52 000 Km^2	1 year	52 000 Km^2	55 years	1961-2015	France	Stable
Pilotto et al.	Abundance	52 000 Km^2	1 year	52 000 Km^2	55 years	1961-2015	France	Stable
Pilotto et al.	Temporal beta-diversity	52 000 Km^2	1 year	52 000 Km^2	55 years	1961-2015	France	Stable

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

Reference	Metric	Spatial grain	Temporal grain	Spatial extent	Temporal extent	Years	Country	Trend
Pilotto et al.	SR	6 155 Km^2	0.08 year	6 155 Km^2	43 years	1975-2017	Netherlands	Increase
Pilotto et al.	Simpson	6 155 Km^2	0.08 year	6 155 Km^2	43 years	1975-2017	Netherlands	Increase
Pilotto et al.	Abundance	6 155 Km^2	0.08 year	6 155 Km^2	43 years	1975-2017	Netherlands	Increase
Pilotto et al.	Temporal beta-diversity	6 155 Km^2	0.08 year	6 155 Km^2	43 years	1975-2017	Netherlands	Stable
Pilotto et al.	SR	2 180 Km^2	1 year	2 180 Km^2	45 years	1974-2018	Netherlands	Decrease
Pilotto et al.	Simpson	2 180 Km^2	1 year	2 180 Km^2	45 years	1974-2018	Netherlands	Increase
Pilotto et al.	Abundance	2 180 Km^2	1 year	2 180 Km^2	45 years	1974-2018	Netherlands	Stable
Pilotto et al.	Temporal beta-diversity	2 180 Km^2	1 year	2 180 Km^2	45 years	1974-2018	Netherlands	Decrease

Supplementary materials

Table 2.2: Supplementary informations on each trend

Reference	Trend	Note
Barnagaud et al.	Increase	circle of radius 400 m
Barnagaud et al.	Decrease	NA
Barnagaud et al.	Increase	NA
Barnagaud et al.	Increase	NA
Barnagaud et al.	Stable	NA
Barnagaud et al.	Increase	NA
Roels et al.	Increase	Before/after tree planting (increase 11 times)
Roels et al.	Increase	Before/after tree planting (increase 3 times)
Wretenberg et al.	Decrease	looking at the trend through different environmental policies, ” local species richness (i.e. at the scale of sites) decreased significantly probably as a result of an overall reduced abundance of several species. ”
Ram et al.	Increase	forest species, road of 8 Km with no limitations so assumed 200m, ”species richness (the average number of species seen per route and year) ”
Ram et al.	Stable	forest specialist species, road of 8 Km with no limitations so assumed 200m
Ram et al.	Increase	generalist species, road of 8 Km with no limitations so assumed 200m
Ram et al.	Increase	specialist species, road of 8 Km with no limitations so assumed 200m
Ram et al.	Increase	generalists species, road of 8 Km with no limitations so assumed 200m
Harrison et al. (b)	Increase	”Biodiversity as measured by the geometric mean of relative abundances has generally increased since 1994”, Visited twice a year / Increase first half and second second half
Harrison et al. (b)	Stable	” 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 2.2: Supplementary informations on each trend *(continued)*

Reference	Trend	Note
Harrison et al. (b)	Stable	” 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
Doxa et al.	Increase	Not sure for the spatial scales, HNV +6.5%
Doxa et al.	Stable	Not sure for the spatial scales, for HNV +1.1%, Decrease then come back to the initial value
Doxa et al.	Stable	Not sure for the spatial scales, national, Decrease then come back to the initial value
Arnold et al.	Stable	Non significant slight increase
Arnold et al.	Stable	Non significant slight increase
Arnold et al.	Stable	Non significant slight increase
Xu et al.	Decrease	Not sure for the spatial scales, Urbanisation of the study area
Jiguet et al.	Increase	Not sure for the spatial scales, Generalist Bird Indicator, +20%
Jiguet et al.	Increase	Not sure for the spatial scales, Woodland Bird Indicator, -12%
Jiguet et al.	Increase	Not sure for the spatial scales, Urban Bird Indicator, -21%
Jiguet et al.	Increase	Not sure for the spatial scales, Farmland Bird Indicator, -12%
Jiguet et al.	Increase	Not sure for the spatial scales, plus 23%
Jiguet et al.	Decrease	minus 75%
Keten	Stable	NA
Davey et al.	Increase	NA
Davey et al.	Increase	NA
Davey et al.	Increase	NA
Christian et al.	Increase	Temporal grains varies a lot,significant increase of SR
Dittrich et al.	Increase	Spatial grain is the mean area of the orchards, increase sr may be due to increase in sampling effort (2 months for the first period and five for the 2nd and 3rd periods)

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

Reference	Trend	Note
Dittrich et al.	Increase	Spatial grain is the mean area of the orchards, increase sr may be due to increase in sampling effort (2 months for the first period and five for the 2nd and 3rd periods)
Dittrich et al.	Stable	Increase until April then decrease but overall stable, spatial grain is the mean area of the orchards
Dittrich et al.	Stable	Spatial grain is the mean area of the orchards
Sirami and Monadjem	Decrease	NA
García-Navas et al.	Decrease	sorensen score
McGeoch et al.	Decrease	Red list index data, very heterogeneous
Ellis et al.	Stable	Riparian continuous ecosystem, area = 32 x pi x (402), spatial extent = Bear Valley of southern Grant County and Silvies Valley of northern Harney County in east-central Oregon, slight variations in sr but not exceeding se
Ellis et al.	Stable	Riparian discontinuous ecosystem, area = 32 x pi x (402)
Ellis et al.	Increase	Riparian herbaceous ecosystem, area = 32 x pi x (402)
Ellis et al.	Stable	Riparian total ecosystem, area = area = 32 x pi x (402)
Ellis et al.	Increase	Riparian continuous ecosystem, area = 32 x pi x (402), spatial extent = Bear Valley of southern Grant County and Silvies Valley of northern Harney County in east-central Oregon, slight variations in sr but not exceeding se
Ellis et al.	Decrease	Riparian discontinuous ecosystem, slight decrease, area = 32 x pi x (402)
Ellis et al.	Increase	Riparian herbaceous ecosystem, area = 32*pi*(402)
Ellis et al.	Increase	Riparian total ecosystem, area = area = 32 x pi x (402) x 3
Ellis et al.	Increase	Riparian continuous ecosystem, area =32 x pi x (402), spatial extent = Bear Valley of southern Grant County and Silvies Valley of northern Harney County in east-central Oregon, slight variations in sr but not exceeding se
Ellis et al.	Decrease	Riparian discontinuous ecosystem, area = 32 x pi x (402)

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

Reference	Trend	Note
Ellis et al.	Increase	Riparian herbaceous ecosystem, area = 32 x pi x (402)
Ellis et al.	Decrease	Riparian total ecosystem, slight decrease, area = 32 x pi x (402)
Sicurella et al.	Stable	NPA non protected area
Sicurella et al.	Stable	NR nature reserves
Sicurella et al.	Increase	RP regional parks
Nally	Increase	NA
Latta et al.	Decrease	54 to 31 species, untouched forest
Latta et al.	Decrease	67 to 30 species, introduced tree species in the forest
Scarton	Increase	14 to 25 species
Scarton	Increase	2.07 to 2.38
Scarton	Increase	2.07 to 2.38
Scarton	Increase	2.07 to 2.38
Chiron et al.	Decrease	Prediction with baseline scenario
Chiron et al.	Decrease	Prediction with CAP greening cenario
Chiron et al.	Decrease	Prediction with No Pillar I scenario
Chiron et al.	Decrease	Prediction with biofuel scenario
Eglington and Pearce-Higgins	Decrease	From 1 to 0.5
Harrison et al. (a)	Stable	Farmland communities
Harrison et al. (a)	Decrease	Farmland communities, GoF weighted towards the rare species
Harrison et al. (a)	Increase	Farmland communities, GoF weighted towards the common species
Harrison et al. (a)	Increase	Farmland communities
Harrison et al. (a)	Stable	Farmland communities, GoF weighted towards the rare species
Harrison et al. (a)	Increase	Farmland communities, GoF weighted towards the common species

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

Reference	Trend	Note
Harrison et al. (a)	Stable	Farmland communities
Harrison et al. (a)	Stable	Farmland communities, GoF weighted towards the rare species
Harrison et al. (a)	Stable	Farmland communities, GoF weighted towards the common species
Harrison et al. (a)	Decrease	Farmland communities
Harrison et al. (a)	Decrease	Farmland communities, GoF weighted towards the rare species
Harrison et al. (a)	Stable	Farmland communities, GoF weighted towards the common species
Harrison et al. (a)	Increase	Woodland communities, supplemtary material
Harrison et al. (a)	Stable	Woodland communities, supplemtary material
Harrison et al. (a)	Decrease	Woodland communities, supplemtary material
Harrison et al. (a)	Increase	Woodland communities
Harrison et al. (a)	Increase	Woodland communities
Harrison et al. (a)	Stable	not sure for the trend, Woodland communities
Harrison et al. (a)	Increase	Woodland communities
Harrison et al. (a)	Decrease	Not sure for the trend, Woodland communities
Harrison et al. (a)	Stable	Not sure for the trend, Woodland communities
Harrison et al. (a)	Stable	Not sure for the trend, Woodland communities
Harrison et al. (a)	Stable	Not sure for the trend, Woodland communities
Harrison et al. (a)	Increase	Not sure for the trend, Woodland communities
Juslén et al.	Decrease	NA
Normander et al.	Decrease	Farmland
Normander et al.	Stable	Forest
Normander et al.	Decrease	Mires
Schipper et al.	Increase	All

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

Reference	Trend	Note
Schipper et al.	Decrease	Grassland
Schipper et al.	Increase	Woodland
Schipper et al.	Increase	Wetland
Schipper et al.	Stable	Shrubland
Schipper et al.	Increase	All
Schipper et al.	Decrease	Grassland
Schipper et al.	Increase	Woodland
Schipper et al.	Increase	Wetland
Schipper et al.	Stable	Shrubland
Schipper et al.	Increase	All
Schipper et al.	Decrease	Grassland
Schipper et al.	Increase	Woodland
Schipper et al.	Increase	Wetland
Schipper et al.	Increase	Shrubland
Schipper et al.	Increase	All
Schipper et al.	Stable	Grassland
Schipper et al.	Increase	Woodland
Schipper et al.	Increase	Wetland
Schipper et al.	Increase	Shrubland
Schipper et al.	Increase	All
Schipper et al.	Decrease	Grassland
Schipper et al.	Increase	Woodland
Schipper et al.	Increase	Wetland

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

Reference	Trend	Note
Schipper et al.	Decrease	Shrubland
Schipper et al.	Increase	All
Schipper et al.	Increase	Grassland
Schipper et al.	Decrease	Woodland
Schipper et al.	Increase	Wetland
Schipper et al.	Increase	Shrubland
Schipper et al.	Decrease	All
Schipper et al.	Increase	Grassland
Schipper et al.	Decrease	Woodland
Schipper et al.	Decrease	Wetland
Schipper et al.	Decrease	Shrubland
Schipper et al.	Increase	All
Schipper et al.	Increase	Grassland
Schipper et al.	Increase	Woodland
Schipper et al.	Increase	Wetland
Schipper et al.	Decrease	Shrubland
Pilotto et al.	Decrease	Dataset S004, temporal grain = 1 month
Pilotto et al.	Increase	Dataset S004, temporal grain = 1 month
Pilotto et al.	Decrease	Dataset S004, temporal grain = 1 month
Pilotto et al.	Stable	Dataset S004, temporal grain = 1 month, p-val = 0.8
Pilotto et al.	Increase	Dataset S011
Pilotto et al.	Stable	Dataset S011, p-val = 0.8
Pilotto et al.	Increase	Dataset S011

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

Reference	Trend	Note
Pilotto et al.	Decrease	Dataset S011
Pilotto et al.	Increase	Dataset S012
Pilotto et al.	Stable	Dataset S012, p-val = 0.1
Pilotto et al.	Stable	Dataset S012, p-val = 0.22
Pilotto et al.	Stable	Dataset S012, p-val = 0.9
Pilotto et al.	Increase	Dataset S013
Pilotto et al.	Increase	Dataset S013
Pilotto et al.	Stable	Dataset S013
Pilotto et al.	Stable	Dataset S013
Pilotto et al.	Increase	Dataset S047
Pilotto et al.	Increase	Dataset S047
Pilotto et al.	Increase	Dataset S047
Pilotto et al.	Decrease	Dataset S047
Pilotto et al.	Stable	Dataset S076
Pilotto et al.	Stable	Dataset S076
Pilotto et al.	Stable	Dataset S076
Pilotto et al.	Stable	Dataset S076
Pilotto et al.	Increase	Dataset S094
Pilotto et al.	Increase	Dataset S094
Pilotto et al.	Increase	Dataset S094
Pilotto et al.	Stable	Dataset S094
Pilotto et al.	Decrease	Dataset S095
Pilotto et al.	Increase	Dataset S095

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

Reference	Trend	Note
Pilotto et al.	Stable	Dataset S095, p-val = 0.056
Pilotto et al.	Decrease	Dataset S095

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