

**THE INFLUENCE OF ACCESSIBILITY TO CITIES ON BIODIVERSITY CHANGE**

*By*

**DANIELA GARGYA**

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# Abstract/ Summary

Globally, biodiversity is changing in complex ways in a time of accelerating human impact. We know little about how large-scale anthropogenic activity, as a prominent contemporary global change driver, is influencing the reshuffling of ecological communities. I quantify the influence on ecological assemblages by human activities, such as roads and urbanisation, worldwide and across taxa by analysing change in 181 time series studies. I predict to find higher temporal and spatial turnover with greater exposure to roads and urbanisation. Linking human impact with biodiversity change can provide the needed evidence and predictions for better international policy making in the light of our rapidly changing Anthropocene.

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# Acknowledgments

I would like to thank blab la and blab la.

# List of abbreviations

# Introduction

* *Split objectives?*
* *Is last paragraph intro same as objectives and RQ part?*

*The dissertation comprises an introduction discussing the research question, reviewing the relevant literature, and setting out the research questions and hypotheses to be tested. The introduction should introduce the reader to the subject area and clarify the knowledge gap that the dissertation research will fill. The Introduction must set the context for the dissertation by reviewing the relevant literature. The primary research questions and hypotheses should be listed in the final paragraph of the introduction. The introduction should not be just a ‘Literature Review’ but should include relevant references to general (theoretical papers and reviews) and specific (specific to the particular question addressed) literature, to justify the research that has been undertaken and define the question being addressed.*

## Background (not sure whether to title this section)

## focus more on previous studies? Specific vs broad?

## [file:///C:/Users/DanielaG/Downloads/DePalmaetal\_Preprint.pdf](file:///C:\Users\DanielaG\Downloads\DePalmaetal_Preprint.pdf)

## Declines in beta diversity can reduce the resilience of communities to environmental changes and alter food‐web structure (Olden et al. [2004](https://onlinelibrary.wiley.com/doi/full/10.1111/ecog.01932#bib-0044)). (Newbold <https://onlinelibrary.wiley.com/doi/full/10.1111/ecog.01932>)

## Eternal question: what drives biodiversity change

Globally, biodiversity is changing in complex ways in a time of accelerating human impact. Land-use changes through anthopogenic activity are expected to rise by XX, further influencing BD. Large scale human impact has profoundly altered abundance, richness and composition of ecological assemblages// *infleunces on BD through urbanisaton, roads, invasion, habitat fragmentation*. *Impairment of assemblages can lead to reduced ecosystem resilience. One of most prominent BD change is ecological reshuffling.* Disentangling drivers of complex biodiversity change and establishing effective conservation practices without compromising human development is an urgent issue. Currently the limited understanding how global change drivers, such as human-induced land-use changes, influence local patterns in biodiversity over time.

Quantification of human influence on natural workd; only XX% can be considered as wilderness anymore. Linking human level of influence to changes in biodiversity. Resulting deterioration of natural system threatens ecosystem resilience and extinction rates. Global assessments have highlighted importance of understanding temporal changes of local communities (link to resilience). Trends in asselblages are best way to measure complex change. Linking local to global? Homogenization? Importance of making global assessment as it reveals other interesting aspects of biodiversity change.

Ecological assemblages are experiencing range of changes, from immigration to extinction and it is important to capture all of them and not only focus on richness and abundance as this is not reflective of what is actually going on. Need to do temporal assessments rather than space-for-time,as they cannot account for ecological lags and community regulation.

Humans have driven biodiversity change through climate change, habitat change, exploitation, pollution and invasive species. Expected rise as on agenda to increase accessibility.

It is difficult to capture different human influences (and their interactions). Here, we attempt to use the metric accessibility which is a measure of the closest travel time to the next urban centre. Taking into account mainly roads (compared to Newbold) and urbanisation. As a proxy for human intense presence, it is also talking about habitat fragmentation, alien species, loss of habitat, as cumulative measure. So far, assessment more focussed on specific type of land-use change (eg forest loss), but here trying to capture cumulative influence in single measure. Mention other studies are attempting to capture a range?

Influence of humans have returned mixed results, with some studies reporting increases of biodiversity due to human influence, whilst other found strong declines (or general finding). Demonstrating a general pattern has been hindered by species-specific interaction between land-use change and biodiversity dynamics, as well as the influence of other drivers on biodiversity change. Other drivers include climate change etc. The interaction of taxa-specific can add to understanding overall and allows more specific targeting of conservation efforts.

Topics to mention

* Anthropogenic influences on global BD/local BD
  + Magnitude and consequences of land-use change
  + consequences ecosystem functioning
  + other global change drivers
  + importance wilderness?
* introducing accessibility as proxy for many human influences
  + roads, urbanisation, invasion etc, alien species potential
* Best ways to measure BD: turnover rather than richness, abundance
  + Importance of termporal trends compared to space-for-time
  + Extinction and immigration -> potential lags
  + Biotic homogenization
* Link global and local BD
* Species/ taxa different responses/ species vulnerability
  + Community regulation
* Global change driver acting together

## Objectives and research questions

*This should be a concise statement of the objectives, research questions and hypotheses of the study. You may also include in this section if you wish. Hypotheses should be explicitly and outline the anticipated results should be discussed: “If hypothesis H1 is supported than this will indicate… However, if H2 is supported that this will suggest…”.*

My aim is to quantify how global change drivers influence ecological communities over time. Specifically, I will focus on the effects of urbanisation and roads, captured in the metric accessibility to cities, and human population density on temporal changes on ecological community composition overall and across taxa. These drivers are an indirect representation of large- scale human activity and capture big parts of the alteration of our planet. I will test if these drivers of global change explain heterogenous biodiversity change found across our planet. To achieve this, I investigate the influence of accessibility to cities on ecological assemblages worldwide and across taxa by analysing change in 5078 time series. I assess variation in biodiversity change across blablabla taxa. I will address the following research questions:

1. Do sites with higher accessibility to cities experience more changes in assemblage composition over time (temporal turnover) than locations with lower accessibility?
   1. How does the duration of ecological monitoring influence the magnitude of detected temporal turnover trends?
2. How does temporal turnover of ecological communities respond to levels of accessibility across taxa (birds, mammals, terrestrial invertebrates, terrestrial plants)?
3. How is temporal turnover influenced by an interaction between human population density and accessibility?

## Research hypotheses

I hypothesize that there will be a positive relationship between higher accessibility to cities and greater temporal turnover. The magnitude of temporal turnover increases for sites which have been monitored over longer durations. When looking at individual taxa, I hypothesize that taxa will have different responses to high and low levels of accessibility, with both positive and negative relationships present. The relationship between accessibility to cities and temporal turnover is steeper, when human population density is higher (all positive). Those hypotheses will be tested against the null hypotheses of no relationship (or negative relationship) between level of accessibility and temporal turnover, and human population density and temporal turnover.

* *Sites with higher accessibility to cities correspond with greater temporal turnover*
* *The magnitude of temporal turnover increases for sites which have been monitored over longer durations*
* *Ecological communities of taxa respond differently to high and low levels of accessibility.*
* *The relationship between accessibility to cities and temporal turnover is steeper, when human population density is higher (all positive)*

## Predictions

https://osf.io/pua5m/?view\_only=575f6a48587245f3b6971235bcf32b3f

I predict greater temporal turnover with greater exposure of accessibility to cities, as an alteration of the natural environment benefits some species, while damaging others, influencing community composition. I predict greater temporal turnover in sites which have been monitored over longer durations, as the effect of turnover becomes more apparent over time. I predict both positive and negative trends to be present among taxa, as they have differences in ecological requirements. I predict the relationship between accessibility and temporal turnover to be steeper, when human population density is higher, as high HPD increases the pressures on the natural systems, leading to higher turnover.

If I find support for my null hypotheses, this will indicate that the metric accessibility to cities cannot capture the most relevant human impact on biodiversity, questioning the justification for humanly undisturbed places. If the results are in line with my alternative hypotheses, this will demonstrate the importance of humanly undisturbed places for the conservation of biodiversity.

We predict larger turnover with larger exposure to all types of global change because the

different drivers all alter ecosystems, which might create beneficial conditions for some

species, and detrimental conditions for others, resulting in community composition

changes43,44.

# Methods

*The methods should explain as concisely as possible where you worked and what you did. Only include the required methods to repeat your study, do not include methods for data you do not present in the dissertation. Standard analyses or techniques need only be given a reference to published accounts or protocols. Use clear subheadings to structure your methods for the reader. Discuss data manipulations, statistical approaches used and the statistical software in a statistical analysis section.*

To quantitively test the consequences on ecological communities of large-scale anthropogenic activity globally, I used 3 global databases.

## Databases

WHERE TO PUT FIGURE BIOTIME?  
ADD OTHER FIGURES?  
SAMPLE SIZES?  
CONCEPTUAL DIAGRAM?  
REASON WHY NO RAREFACTION

***BioTIME Database – biodiversity time series data***

The currently largest database of temporal community time series spans 4,970,128 (UPDATE) records of richness and abundances of species globally, covering a range of taxa, including birds, mammals, invertebrates and plants (Dornelas *et al.*, 2018). I analysed 5788 time series from 181 different studies from terrestrial (UNIQUE?) places around the globe that are part of the BioTIME database as of 12/03/2020. I used all available data that met my inclusion criteria: part of the terrestrial realm, minimum study duration of 5 years, at least 15 studies per taxa, no more than 2000 plots per study, plot fixed to one location and at least 2 survey points per plot. The time-series used represent repeated studies of species abundance and identity of all species found within an ecological community. The data collection of BioTIME was consistent within studies but not between studies.

The BioTIME database is limited in its even representation of different taxa and latitudes. It underrepresents reptiles and amphibians and the tropics and polar regions (see Figure 1).

PROTECTED AREAS?

***Accessibility to cities 2015 data***

To quantify large scale human impact (of roads and urbanisation), I extracted an accessibility to cities metric from the malariaatlas project Accessibility to cities 2015 global database. This database calculates least-cost-path land-based travel time to the nearest densely populated area (between 85 degrees north and 60 degrees south) at a 30 arc seconds X and Y resolution. Areas with >1,500 inhabitants/km² or a majority of built-up land cover types coincident with a population centre of at least 50,000 inhabitants are defined as densely populated areas.

***Human population density dataset***

I derived population density data from the Gridded Population of the World, Version 4: Population Density, Revision 11 database (CIESIN, 2018). Human population density was defined as number of persons per square kilometre, based on national censuses counts and population registers. Data is available 2015 at a 30 arc-second resolution.

## Data processing

MENTION R?  
MENTION PACKAGES?  
MENTION BIOMASS TYPES ETC?   
MENTION THAT BIOTIME WAS NOT STANDARDISED CELL SIZE/SAMPLE EFFORT?  
CENTERING OTHER VARIABLES?  
GLOBAL GRID CELL?  
MENTION BD DOES NOT COVER RANGE OOF ACCESSIBLITY AND HPD? Extra paragraph  
TURNOVER INDEPENDENT OF RICHNESS CHANGE?

I quantified temporal changes in community composition within sites, as the turnover component of beta diversity (species replacement rather than abundance) at the last data point available relative to the first observation data point within the time period outlined above. This was the dominant part of biodiversity change in the BioTIME dataset (REF). I bound the scores of turnovers between zero and one, where zero is no change in community composition and one indicates that all of the original species have been replaced.

I harmonized both accessibility and human population density dataset to a standard global grid size of 25km² by taking the mean value of the grid cell. MENTION SENSITIVITY TO SCALE FROM SENSITVITY ANALYSIS. I bound the scores extracted between zero and one, where zero is not accessible/low human population density and one is very accessible/ high human population density respectively.

## Statistical/data analysis

EXACT MODEL (LINEAR?)  
DISTRIBUTION INTERCEPT ~1? LOGIT LINK FUNCTION? % FALLING INTO EACH CATEGORY (0,1,0-1)  
FORMULAS?

All statistical analysis was conducted in R v. 3.6.1. (REF R). To quantify the influences of accessibility and human population density on turnover of ecological communities, I used a hierarchical Bayesian modelling framework based on a Markov chain Monte Carlo (MCMC) method. All Bayesian models were created in a Stan computational framework and accessed through the {brms} package (REF). The models are based one a zero one inflated beta distribution to reflect the properties of turnover (bound between, and including, zero and one).

**Explanation models response variables, fixed effects, random effects**

CENTERING OF DATA HERE?  
STATE MODEL EQUATION?

I modelled turnover as my response variable. Fixed effects were (scaled) accessibility and duration of the time-series. Area was not included as a fixed effect, as it did not have a significant effect on turnover (SAME FOR DURATION THOUGH?). To answer Research question 3, human population density was included as a fixed effect, as well as the interaction between accessibility and human population density. To account for autocorrelation of both methods and to some extent space, Study ID was included as a random effect. A model including a grid cell, more directly accounting for spatial autocorrelation did not converge, so the term was excluded. Taxa was included as a random effect, as I wanted to remove the variation of different taxa to the overall/ no expected effect taxa and turnover?

Ggpredict?

(Coding scheme for categorical value of human population density)

**Model explanation (priors, iterations).**

The models will be based on a zero one inflated beta distribution.(HERE OR BEFORE?)

I ran the model first with both random intercepts and slopes for taxa but as no model convergence was achieved, I ran them with only random intercept. Allowed turnover to vary by random slope and intercept?

I used the default priors as they are weakly informative and I have no ecological backup to assume otherwise. The default priors are:

I ran the models with 6000 iterations, with a warmup of 2000 iterations. Alpha? Treedepth? I assessed convergence visually by examining trace plots and by using Rhat values.

As I will be using a Bayesian framework, my inferences will be based on the posterior distribution of each fixed effect. They will be considered significant if the lower and upper 95% credible intervals don’t overlap zero. I will conclude all results, regardless of the direction or magnitude of the effect size.

**Alternatives to measuring variables?**

**Sensitivity analysis**Different scales extraction  
Better temporally matched data

Full R script in appendix, preregistration

# Results

*The Results Section contains text that summarises the findings of the research referring to all figures, tables and statistical results. Include the primary results, ordered logically (often from most important to least works well). Maintain the order that you present your results through out all parts of the dissertation. Data should only be presented once in either tables or figures in the main text or appendix. Often, it is recommended to write the results section first, so that you can write the methods that are appropriate to describe the results presented, then you can write the discussion next about these results, the introduction to introduce the relevant literature for the scientific story that you are telling and finally the conclusions and abstract – this approach is called writing backwards.*

*Statistical results when reported in the text, tables or figure captions must include the test used (ANOVA, Linear model, Linear mixed effects model, GLM, etc.), sample size (N) or degrees of freedom, effect size and error (e.g., slope and error around the slope), test statistic (t-value, F statistic, etc.), model fit (R2, pseudo R2, etc.) if appropriate and p-value. P-values alone are incomplete statistical reporting (see http://www.nature.com/news/statisticians-issue-warning-overmisuse-of-p-values-1.19503). Full statistical results, additional figures or tables and raw data can be included in an Appendix. For guidelines on how to report specific statistical tests refer to the scientific*

*literature and discuss you're your supervisor. All code for statistical analyses should be included in the appendix for students that are using coding based statistical software such as R.*

*Questions:*

* *How to put sample size*
* *Limitations of results in results section?*
* *Visualising vs modelling*
* *Include sensitivity analysis here?*
* *Put distribution of variables?*

Standardized effect sizes were calculated by dividing the model slopes by the standard deviation of the dependent variable

**Temporal turnover and accessibility (Research Question 1)**

1. Do sites with higher accessibility to cities experience more changes in assemblage composition over time (temporal turnover) than locations with lower accessibility?

How does the duration of ecological monitoring influence the magnitude of detected temporal turnover trends?

Contrary to my predictions, I found that temporal turnover has decreased as accessibility is increasing across the 5787 time-series surveyed (slope = -1.05, CI = -1.59 to -0.51, Figure 1, see Table 1 for more model outputs). On average, for every 10% increase in accessibility, turnover increases by 4%.

For every 10% increase in accessibility, communities become 5% more similar

temporal turnover is decreasing by 10% as accessibility is increasing by 10%. In line with my predictions (see preregistration), the duration of the observation influenced the magnitude of the detected temporal turnover trends, with higher turnover increases for longer observations of sites.

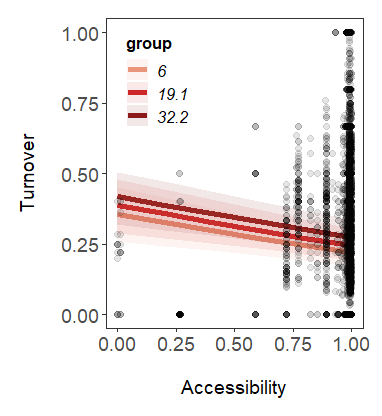


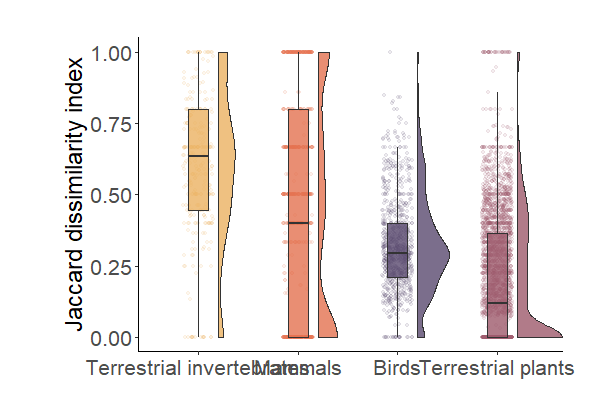
Figure 2. Jaccard turnover has increased for higher levels of accessibility across 5788 time-series globally (slope = 0.05, CI = 0.03 to 0.07, Figure 1, see Table 1 for more model outputs). Grey points represent raw data. Lines and error bands represent model predictions and 95% credible intervals, respectively. Colour coding of lines represent differing duration of monitoring. See trace plots and model Rhat values in appendix confirming model convergence.

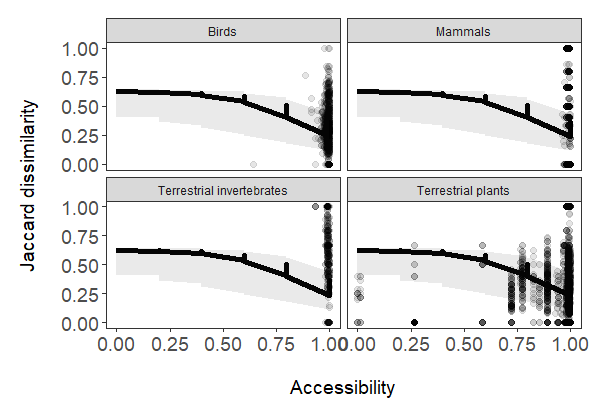
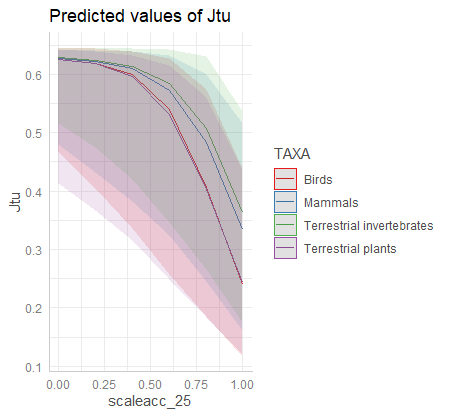
*The results of the temporal turnover model revealed an increase of temporal turnover across levels of accessibility. Therefore, I found support of my initial prediction of accessibility increasing temporal turnover, and thus accept the alternative hypothesis. Study area had no significant effect on temporal turnover (slope = 0.05, CI = - 0.03 to 0.07). Latitude? Results to be taken with caution?* Examining the posterior means of the random terms, study ID, taxa and broad grid cell, revealed among Study ID variation (variance = 0.4, CI 0.3 – 0.5), and little within study ID variation (variance blabla). Same for taxa and broad grid cell. Full model output can be found in Appendix X.

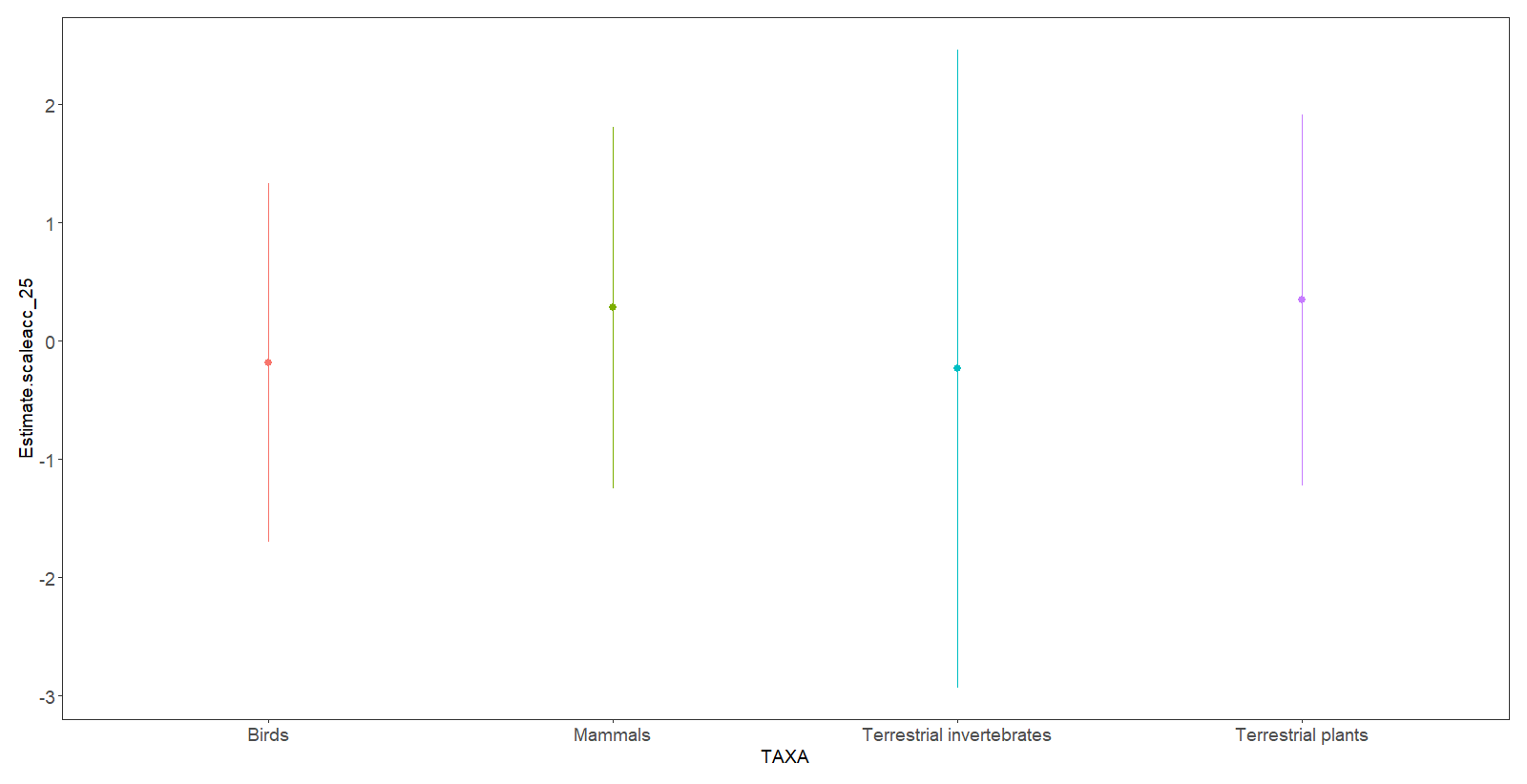
**Taxa-specific responses to different levels of accessibility (Research Question 2)**

Quantification of results?

Visualising raw temporal turnover data among taxa revealed no clear differences between the temporal turnover of individual taxa on different levels of accessibility (Figure 3). Terrestrial plants’ and birds’ responses, have increased turnover as accessibility is increasing. Among the 4 taxa, terrestrial plants have experiences the greatest temporal turnover increase by 23% for every 10% increase in accessibility. Mammals and terrerstrial invertebrates show no clear pattern. TALK ABOUT DISTRIBUTION OF DATA?







BAR PLOT/ BOX PLOT WITH EFFECT SIZES OF EACH TAXA

SCATTER PLOT FOR EACH TAXA?

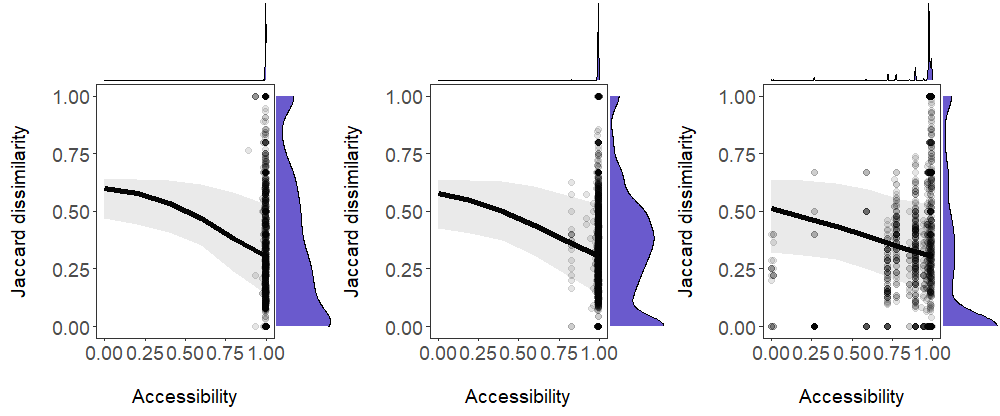
The model which compared temporal turnover among taxa revealed that there is no significant difference between taxa’s individual temporal turnover response on accessibility (slope blabla). Interaction taxa:accessibility?. 2 responede, 2 not. Caution with interpretation?

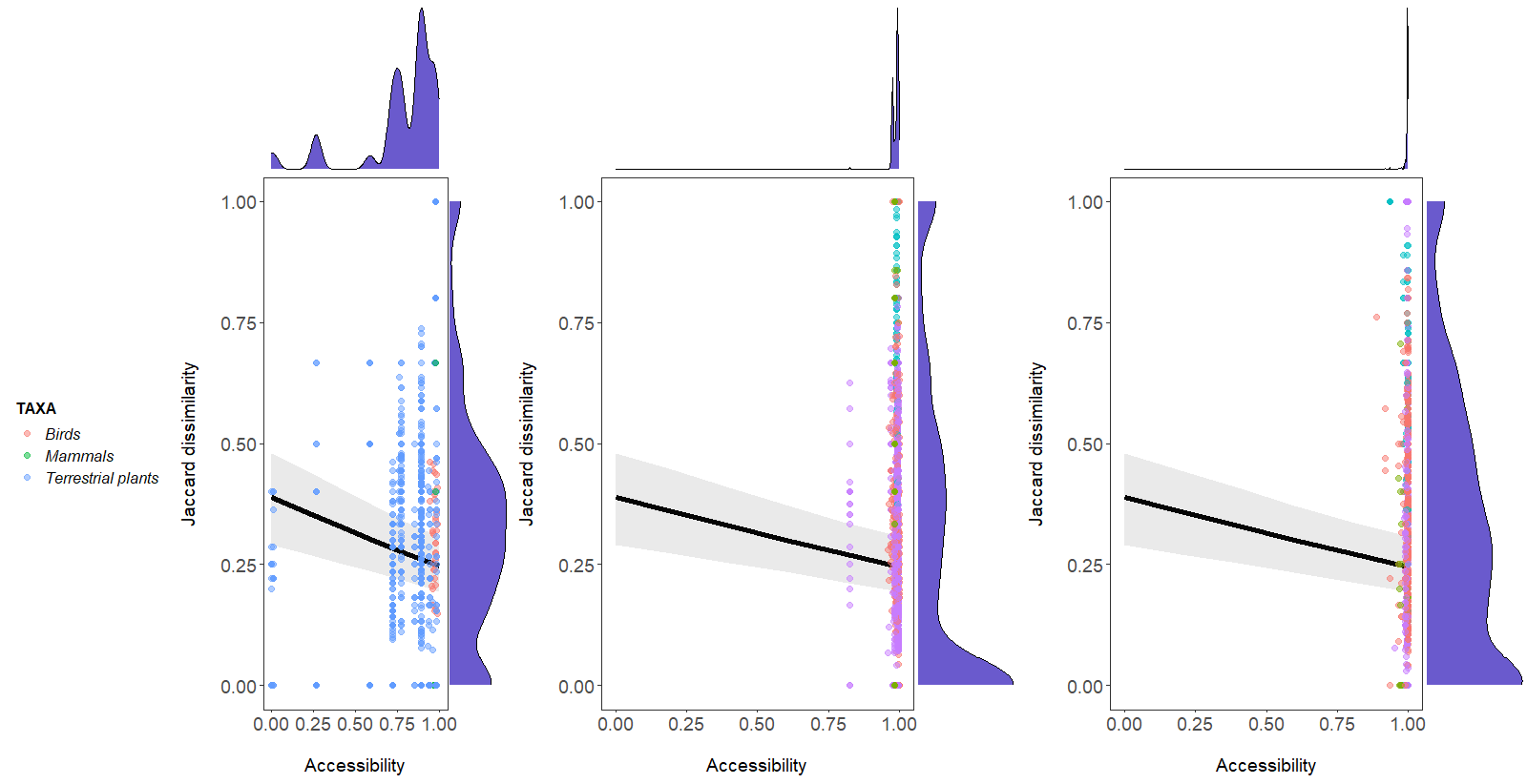
Model predictions confirmed my hypothesis of.. mention other fixed effect response tp that. + random terms

Sensitivity analysis results?

Visual examination trace plots, model convergence, shortcomings of the model

**Relationship between accessibility and human population density on temporal turnover (Research Question 3)**





# Discussion

*The object of the discussion is to summarise your major findings and place your findings in the context of previous studies current state of knowledge in the literature. When you discuss your own work and that of others, back up your opinions with evidence and citations. The first paragraph of the discussion should contain a summary of your major findings (usually 2 – 4 points) and a brief summary of the implications of your findings and should make reference to whether you found support for your hypotheses or how you answered your research questions. The following paragraphs will usually describe each of these findings in greater detail making reference to previous studies. Often the discussion will include a paragraph describing the limitations of your study and the potential for future research.*

*Recap biological result 1,2,3 -> together these suggest X*

*Choose 3 reasons why not*

*Rest: limitations on why #1-#3 aren’t perfect for proving X but can argue that they’re pretty good, and you can put X back into the context of the literature again.*

Main findings  
My analysis of 5788 time-series in XX unique locations globally did not show an increase of turnover with increasing accessibility. Contrary to my prediction, turnover was XX% higher in less accessible sites, suggesting a rejection of my hypothesis of a positive relationship between turnover and increasing accessibility. I demonstrate that higher human impact captured in the proxy accessibility have not led to increased biodiversity change. Furthermore, I provide evidence for possible negative responses to low accessibility, questioning our current understanding of benefits of sites with low human impact (such as protected areas). The lack of positive responses of turnover to accessibility could be due to the unaccounted indirect large-scale human impact , complexity of real-world biodiversity change, and interactions between different effects of human impacts and (*mismatches between magnitude, scale, timing, location and metric of capturing of human impact*). The taxa-specific relationships between accessibility and turnover demonstrate that all studied taxa experience higher turnover at lower accessibility with decreasing biodiversity change as accessibility increases. My findings of negative responses to low accessibility highlight the complexity of real-world communities and the importance for considering temporal dynamics and interactive effects of land-use change when planning and implementing conservation schemes (refer back to possible reasons).

**Accessibility and human impact**Intro with accessibility and SD goals  
  
Difference influences accessibility and their relation to turnover: roads, urbanisation, alien species, land-use change from natural to agriculture, pollution, habitat fragmentation  
Studies showing turnover higher for alien species, urbanisation, other studies showing turnover lower?

Special nature of accessibility  
many different human impacts -> potential for antagonistic effects  
quite large scale, but we might still not capture influences outside or we actually don’t know what biodiversity change is happening outside? Baseline is high and human impact are lowering vs more influence (Baseline is way smaller as calculated by dornelas)

I found no evidence of lower turnover in less accessible places (on any of the 4 target taxa), which could be because of uncaptured indirect human impacts in areas where human impact seems to be low. On the one hand human impacts captured with the metric accessibility such as blabla, have rather shown biodiversity declines (metrics richness and population trends; few temporal turnover), but they were all related to direct impacts and haven’t yet accounted for impacts human might have beyond what has been assumed they influence. As this analysis concerns large landscape scale lens, the impacts seem to go even further.  
  
How good is accessibility at capturing human impact (refer also to hpd?)  
  
High accessibility can be seen as a proxy for different human impacts. Main improvements from the previous accessibility dataset are the inclusion of roads. Furthermore, it represents human impacts such as urbanisation, higher invasive species potential through higher connection (roads and transport), land-use change. These alterations to the natural environment have a track-record of negative effects such as habitat degradation, resource availability. Urbanisation can favour urban adapted species over more-niche species. Extinction rates are higher than speciation rates. Changing habitats and often making them more similar favours certain species over others, driving some to extinction and allowing immigration of new species. For understanding biodiversity change, as it is decoupled from richness trend, we need to look at that level to understand. Places with low accessibility do not reflect that species are not changing rapidly in those locations, questioning wilderness areas. Habitat fragmentation point for diverging findings. Extinction debt and immigration credits. + pollution and light pollution etc

**Why temporal turnover decreases with more accessibility?**It is more important about scale of impact; . Mismatch between protected areas and human impact -> protected areas still affected by larger scale human impact. Same shown here as temporal turnover increased in less accessible sites. -> importance of real world data compared to modelling approaches (Newbold and di marco). -> mismatch between assemblages monitored and localised impact of accessibility.

**Importance of temporal dynamics of real-world data**

split in explanation high and low accessibility?

I found no evidence for decreasing biodiversity change as accessibility is increasing (Figure 2), which could be because of a mismatch between the record of the potential negative impact of human impact and the response of the ecological community. Other studies who have taken them into account came to similar conclusions (bring earlier). These have also accounted for Before-After-Impact which was not possible here. While the time-series span an average duration of 12 years (+/-), the accessibility is a one point in time variable of the nominal year of 2015. To some extent it can be considered as a cumulative variable as accessibility has increased globally (adding roads was most important update since last time). Ecological communities react varied to disturbances. Similar studies of land-use change have found that change in biodiversity occurred 6-13 years after peak land-use change. Most human impacts related to accessibility such as roads and urban centres have been present before the monitoring period of the time-series (early 20th century). Thus, past oeak biodiversity change caused by human impact related to accessibility might not have been recorded and taken into account.

Furthermore, ecological lags play an important role and can last up to 50 years. Taking that into account, it is difficult to estimate both the initial human disturbance which influences ecological communities both short and long-term. Studies which have not taken temporal dynamics into account have found contradicting results of increasing biodiversity change with increasing human impact, because rather used space-for-time or modelling . My findings highlight the complexity of biodiversity change and the need to consider temporal dynamics in the response of ecological communities to land-use change as well as importance of using real-world data opposed to modelling.

Di Marco and colleagues ([2019](https://link.springer.com/chapter/10.1007/978-3-030-40502-1_1#CR11)), using a modelling approach, argue that the retention of dedicated areas for the protection of habitat is essential;

… retaining these remaining wilderness areas is essential for the international conservation agenda. Wilderness areas act as a buffer against species loss, as the extinction risk for species within wilderness communities is—on average—less than half that of species in non-wilderness communities. (p 582)

The authors call for targeted protection to ensure areas of high habitat value for biodiversity receive more (rather than less) protection.

Human impacts such as land-use changes are causing heterogeneous patterns across landscapes and do not uniformly lead to biodiversity change. Having higher turnover at less accessible sites challenges the current assumption that so-called wilderness areas are beneficial for species. Studies so far have mainly focussed on population and richness trends, but the picture revealed in studies that are looking at turnover metrices reveal a more complex picture (Gergana) with both positive and negative trends present. Previous studies that have focussed on space-for-time (Newbold) did not capture temporal changes and thus cannot reflect on what is going on in individual communities.  
Findings highlihght full spectrum of biodiversity responses to accessibility highlight complexity of real-worl communities that might be overlooked in analysis that use space-for-time substitution and do not capture temporal dynamics of ecological responses to land-use change

Community self-regulation. Disturbance is disturbance and does not depend on magnitude of change?

Mismatch between assemblages monitored and localised impacts of accessibility. Scale analysis revealed that trends are stronger when larger scale is taking into account. However X% of studies only have 1km or less extent and not all studies had their unique location making it difficult to give unique value of accesisblity. But also quite likely that a broader scale is more reflectant of human impact as it works on broader scale rather than smaller scale.

**Other drivers affecting biodiversity change and possible interactions**

The coincidence between the presence of other drivers and/or their potential interaction with impacts captured in accessibility might explain higher turnover in less accessible sites. Next to land-use change, climate change is a common global driver of biodiversity change. Climate change displays geographic heterogenous patterns. Recent studies have created maps of global anthropogenic threats including climate change and other large scale human impacts, joining effects of multiple drivers. Less accessible sites might coincide with regions that are experiencing more extreme climate change, which can lead to biodiversity change (Isla paper?).   
  
As accessibility is proxy for many different kind of human impacts, some might interact. Some might be additive, other antagonist and other interactive. Furthermore, other variables might have affect on turnover, such as climate change and other human pressures; link to further research?

**Accessibility RQ**  
1) Complex BD change

* Importance temporal dynamics
  + Real world vs space for time
  + Timing might be off
  + Ecological lags
  + See Newbold and Di Marco, Gergana
* Important consideration magnitude of accessibility/ heterogeneity of effects
  + Temporal lags (discussed above)
  + Mismatch time of monitoring
  + Other drivers
  + Mismatch scale (local impacts of large scale human activity and assemblages monitored, but also biotic homogenization)
  + Disturbance is disturbance
* Community self-regulation
* Habitat fragmentation mixed results -> importance real world data
* Scale?
* Representation

2) Interaction of effects

**RQ2: Taxa**

Due to problems with model convergence, I can only present results that evaluate the relationship between temporal turnover and taxa and not taxa’s different responses to turnover across levels of accessibility.

I presented taxa-specific relationships between temporal turnover and taxa (Figure 4), in particular showing that terrestrial invertebrates followed by mammals show higher temporal turnover than birds and mammals (QUANTIFICATION). All taxa show some degree of temporal turnover (QUANTIFICATION).

Overall, plants made up 60% of the time-series analysed, followed by mammals (20%), birds (15%) and invertebrates (5%). When considering the coincidence of the sample location with protected areas, overall 32.6%. Within each taxa 39% of plants time-series, mammals 45%, invertebrates 4% and birds < 1%. Showing non-coincidence accessibility and protected area, indicating that human impact is operating at larger scale. All of protected area had accessibility score of 0.9 and above.

Species vulnerability to environmental change varies and depends on their sensitivity and responsiveness to environmental changes. Both vary among taxa according to differences in life history, traits and niche breadth (Sunday).

Species composition is affected by dispersal processes and metacommunity dynamics, where species mobility plays an important role (Vellend, 2010), as does the degree of specialisation in the use of resources (niche width). These processes apply both within taxonomic groups and among. In general, for habitat loss and fragmentation caused by land-use changes more mobile species are better able to move among distant habitat fragments, than less mobile species. Contrary research suggests that more mobile species, having larger home ranges rely on larger habitat patches and therefore might be more sensitive to habitat fragmentation. Additionally, the impact at larger scale is more important for mobile organisms. Interactions between these two processes further play a role as with increased specialisation (narrow niche width) rely more on mobility to succeed than generalist species.

Other influences affecting compositional changes include vulnerability to alien species. Plants exhibit more vulnerability to alien species than more mobile taxa.

Furthermore, ecological lags to disturbances vary between different taxonomic groups (explored above?). Climate change?

Generally, species compositional changes are expected to increase as the degree of human impact is increasing. Similar results have been shown (Newbold) for each taxonomic group. Specialist species were shown to be less common in urban environments than generalists, which were shown for birds, mammals and plants. Again results have been obtained from space-for-time data and thus might not reflect the real-world communities temporal dynamics of ecological communities.

Importance of looking at real-world communities, understanding biodiversity better when looking at compositional changes and considering scale: both at level of impact and observation. Implications for conservation?

RQ3: HPD (wait for now)

Model did not converge, so I could not test the interaction, but worked as fixed effect. Fixed effect revealed no significant relationship with temporal turnover. But also negative impact on iodiversity can vary among countries eg with economy size. Could also be that accessibility is generally high except in very few places, but most studies were actually conducted in remote places with low human pop density?

Methodological limitations  
Data is very unequally distributed (make histogram of both hod and acc in one), suggesting most location are highly accessible but have low human population density. Due to some outliers? Almost no data points representing low accessibility. Results might be influenced by some studies in right lower corner. Taxa not really representative either. But sensitivity analysis with only plants revealed similar results.

# Conclusions

*The conclusion paragraph should put your findings into the broader context of the literature and explain how you have filled the knowledge gap that you have identified in the introduction. This is your chance to present to your reader the major take-home messages of your dissertation research. It should be similar in content to the last sentence of your summary abstract.*

# References

# Appendices