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Geographical variations in the impact of anthropogenic pressures on terrestrial biodiversity

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Declaration

Was the data provided to you or did you collect or assemble it?

Were you responsible for data processing or cleaning, if required?

Were any mathematical models developed by you or by your supervisor?

What role, if any, did your supervisor play in developing the analyses presented?

Introduction

Biodiversity is important because it supports life on earth via the ecosystem services provided. When ecosystems have their biodiversity intact, they can provide services such as clean air and pollination, which makes the earth habitable for humans. Biodiversity loss leads to unstable environments, as ecosystems with low biodiversity are less resistant to change. Biodiversity loss diminishes ecosystem productivity [Duffy et al., 2017] and threatens human well-being [Díaz et al., 2006].

Biodiversity is impacted by both natural and anthropogenic pressures [Nobel et al., 2020], however any mention of 'biodiversity pressures' in this study refers only to the latter. Understanding the impacts of anthropogenic pressures on biodiversity is important for creating accurate policies and conservation strategies. Accurate information about biodiversity pressures can produce more effective conservation strategies, and better informed decisions can be made, including biodiversity-conscious investments. One of many responses to the biodiversity crisis [Ogar et al., 2020] is the beginning of a global movement towards sustainable business and biodiversity-conscious investment [**?**][Forum, 2020][**?**].

Assessing the impact that investments have on biodiversity involves calculating the magnitude of association they have with each biodiversity pressure. Information is often available on the geography of a company's activities, such as where they base their factories or where they source their materials from. In the interest of making estimates about each company's biodiversity impact more accurate, the location of each company's biodiversity-related activities could be considered. If the location and magnitude of a biodiversity pressure is provided (by the company), then information about current local biodiversity and sensitivity of the biome to the pressure, accurate predictions could be made about how biodiversity-friendly such an investment would be.

Given that anthropogenic impact on the environment is worldwide [Plumptre et al., 2021], the question should be raised of whether the geographic location of biodiversity pressures affects their impact on global biodiversity. In other words, are some parts of the world more sensitive to biodiversity pressures than others? For example, does the location that a biodiversity pressure takes place change its impact on global biodiversity (regardless of magnitude)? If such geographic differences exist, they should be taken into account when attributing biodiversity-related merit to investments. Better understanding of biodiversity pressures will aid a better understanding of the implications of investments on natural ecosystems .

Literature Review

Literature is abundant on how biodiversity varies by country reference, and why this may be, including how various direct and indirect pressures correlate with these differences [**?**], [**?**] melusine's paper. Various studies have mapped the magnitude of biodiversity pressures across regions/biomes [Millennium ecosystem assessment, 2005] [**?**], and their spatial couplings [Bowler et al., 2020], however to our knowledge, no prior research has studied geographic differences in sensitivity to such pressures. Bowler et al.(2020) concluded that despite any patterns observed in magnitude of pres-

sures, there will always be variation in biodiversity response to such pressures due to species' varying sensitivities. Research about species-specific sensitivities in each ecosystem is useful for local conservation policy however it would be more useful for large scale projects/policies to have information about the sensitivity of regions/biomes on the whole. The current assumption in literature is that whilst magnitude of exposure varies, sensitivity to biodiversity pressures is constant across biomes [**?**], however there is no research to support this assumption. Hence, studying variation in biome sensitivity would be useful in comparing the impact of pressures in these areas on global biodiversity.

There is adequate research to prove that inter-species responses to biodiversity pressures vary find reference.Given that species vary in their sensitivity, and therefore response, to biodiversity pressures, and that each region of the world comprises different combinations of species groups find reference, there is reason to believe that sensitivity to biodiversity pressure could vary depending on region.

One of the papers which studied sensitivity of species to environmental pressures [**?**], developed a set of sensitivity scores for European species, determining which species will benefit from, be indifferent to, or be negatively affected by environmental change. This 'Bioscore' study used such sensitivity scores to create a tool for predicting the effect of a policy change on Europe's biodiversity. The proportion of affected species in each region was used to map the effects of a change in each biodiversity pressure. The sensitivity scores for each species were obtained from published literature about individual species' responses to change in different environmental variables. The BioScore tool suggests that even if the magnitude of a biodiversity pressure is constant across Europe, biodiversity's response can still vary according to country, due to varying sensitivity of the species within such country. This study is a predictive tool based on published studies about individual species, and a wider-breadth study is necessary to observe worldwide variances in countries sensitivities to biodiversity pressures. The BioScore tool's predictions support the concept that country-wide differences in sensitivity could exist.

A wider spectrum study examined sensitivity to environmental change at a broader level, and found variation between taxa [**?**]. This between-taxa variation further supports the concept that sensitivity to biodiversity pressures could vary between countries, and the authors emphasise that their findings suggest that sensitivity to environmental change should not be assumed to be constant across taxa, as is currently common. This supports the idea that researching differences between countries' sensitivity, could contribute to more accurate predictions of how biodiversity pressures impact biodiversity.

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Studies show impacts of socioeconomic status and cultural impacts on biodiversity [Kinzig et al., 2005]. This gives reason to believe that pressures impacting biodiversity loss could have varying impacts based on their location. This research aims to investigate whether the location of a pressure affects its' level of impact on biodiversity.

Methods

The focus of this study is on anthropogenic biodiversity pressures only. Anthropogenic pressures on biodiversity are typically grouped, in the current literature, into 5 official pressures; climate change, land use change, pollution, invasive species and overexploitation. In order to assess whether sen-

sitivity to each pressure varies by country, data was needed in the form of time series (how each of these pressures had been changing in each country over time, as well as how each country's biodiversity had been changing over time). The time series of biodiversity in a country was compared to the time series of a pressure on biodiversity in that country, in order to extract a 'sensitivity score' for each country to assess any effect of geography.

For each biodiversity pressure, a linear model was created for each country using time series of biodiversity data and the corresponding pressure's time series. For each country in which the pressure was found to have a significant effect on biodiversity (p¡0.05), the sensitivity score was noted, representing such country's 'sensitivity' to this particular biodiversity pressure.

The variable chosen to represent biodiversity was biodiversity intactness. The National History Museum's Biodiversity Intactness Index (BII) was chosen as it presents biodiversity in the context of how many original species remain. This allows for direct comparison of these changes, with the changes in antropogenic pressures.

The first biodiversity pressure to be examined was climate change. Time series data for climate change was obtained in the form of annual average temperature for each country. The temperature dataset chosen was from the World Bank's Climate Change Knowledge Portal. This dataset was chosen because it contains comprehensive historical data, providing an annual average temperature for every year from 1900 until 2020.

Results

Discussion

Conclusion

optional section

Data and Code Availability

Data and CodeAvailabilitystatement: At the end of your Main text, before the References section, you must provide a statement titled “Data and Code Availability”, where you name a data (e.g., Dropbox, FigShare, Zenodo, etc) and a code (e.g., Dropbox, GitHub, etc.) archive 20from where the data and code can be obtained that will allow replication of your results. The code may be in the form of a single script file.

References

[Bowler et al., 2020] Bowler, D. E., Bjorkman, A. D., Dornelas, M., Myers-Smith, I. H., Navarro, L. M., Niamir, A., Supp, S. R., Waldock, C., Winter, M., Vellend, M., et al. (2020). Mapping human pressures on biodiversity across the planet uncovers anthropogenic threat complexes. *People and Nature*, 2(2):380–394.

[Díaz et al., 2006] Díaz, S., Fargione, J., Chapin III, F. S., and Tilman, D. (2006). Biodiversity loss threatens human well-being. *PLoS biology*, 4(8):e277.

[Duffy et al., 2017] Duffy, J. E., Godwin, C. M., and Cardinale, B. J. (2017). Biodiversity effects in the wild are common and as strong as key drivers of productivity. *Nature*, 549(7671):261–264.

[Forum, 2020] Forum, W. E. (2020). New nature economy series nature risk rising ... - world economic forum.

[Kinzig et al., 2005] Kinzig, A. P., Warren, P., Martin, C., Hope, D., and Katti, M. (2005). The effects of human socioeconomic status and cultural characteristics on urban patterns of biodiversity. *Ecology and Society*, 10(1).

[Millennium ecosystem assessment, 2005] Millennium ecosystem assessment, M. (2005). *Ecosystems and human well-being*, volume 5. Island press Washington, DC.

[Nobel et al., 2020] Nobel, A., Lizin, S., Brouwer, R., Stern, D., B Bruns, S., Malina, R., et al. (2020). Are anthropogenic pressures on biodiversity valued differently than natural ones? a meta-analysis of the non-use valuation literature. In *2020 Conference (64th), February 12-14, 2020, Perth, Western Australia*, number 305246. Australian Agricultural and Resource Economics Society.

[Ogar et al., 2020] Ogar, E., Pecl, G., and Mustonen, T. (2020). Science must embrace traditional and indigenous knowledge to solve our biodiversity crisis. *One Earth*, 3(2):162–165.

[Plumptre et al., 2021] Plumptre, A. J., Baisero, D., Belote, R. T., Vázquez-Domínguez, E., Faurby, S., Jdrzejewski, W., Kiara, H., Kühl, H., Benítez-López, A., Luna-Aranguré, C., et al. (2021). Where might we find ecologically intact communities? *Frontiers in Forests and Global Change*, 4:26.

[PRI, 2020] PRI (2020). Investor action on biodiversity.

[Sala et al., 2000] Sala, O. E., Stuart Chapin, F., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L. F., Jackson, R. B., Kinzig, A., et al. (2000). Global biodiversity scenarios for the year 2100. *science*, 287(5459):1770–1774.

[WWF, 2020] WWF (2020). Nature is too big to fail.