EXAMINING ENVIRONMENTAL VARIABILITY IN PROTECTED AREAS ACROSS CANADA

Rekha Marcus[1,2], Stefano Mezzini[1,2], Michael J. Noonan[1,2,3]

[1]Department of Biology, The University of British Columbia Okanagan, Kelowna, British Columbia, Canada [2]Okanagan Institute for Biodiversity, Resilience, and Ecosystem Services, The University of British Columbia Okanagan, Kelowna, British Columbia, Canada [3]Department of Computer Science, Math, Physics, and Statistics, UBC Okanagan, Kelowna, British Columbia, Canada

Aims

1) Create a method by which the environmental variability of an area can be determined.
2) Assess the environmental variability of currently established protected areas in Canada to determine their effectiveness.

Introduction

With climate change, environmental variability is expected to increase (Field et. al., 2012). Climate refugia are places that experience less change in relation to the areas around them, suggesting that they can buffer against the effects of climate change. Given that protected areas are created with the purpose of protecting aganist the effects of climate change when possible (IUCN 2008) , we should aim to protect climate refugia. However, there is little consensus on how to identify these refugia. A key component of identifying refugia is determining environmental variability in order to protect regions of low variability.

Literature Review

We first conducted a literature review of the peer-reviewed literature on priority conservation areas. We found that only 4% of the sampled literature incorporated changing environmental variability into their analysis to recommend protected areas.

Methodology

Using daily Normalized Difference Vegetation Index (NDVI; a measure of ecosystem health and productivity) from 1980 to 2023, at a 50 square km resolution, Canadian protected areas larger than 50 square km, and Canadian ecozones, we constructed a method to assess variance (aka environmental variability):

- Generalized Additive Modelling (GAM; a type of regression modelling) was used to understand trends in mean NDVI
- Variance of the residuals of the model (observed - predicted NDVI) was calculated to find the variance of each 50 square km pixel

Figure 1: Map of terrestrial Canadian protected areas with a size larger than 50 square kilometres (n = 1018) as defined by the Canadian Protected and Conserved Areas Database (Environment and Climate Change Canada, 2018).

Results

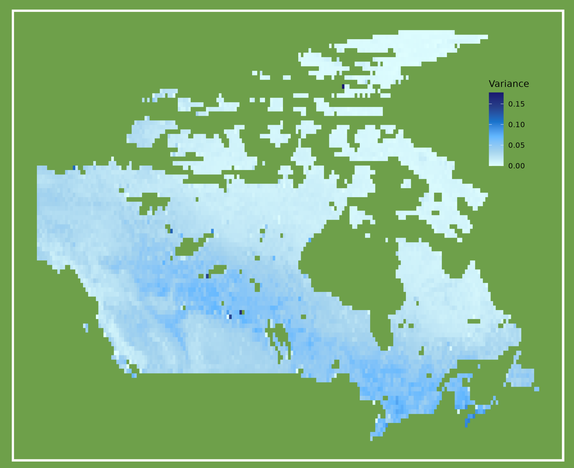

Figure 2: Variance in residuals of modelled NDVI across Canada. Each individual pixel represents a 50 square km area for which the variance was assessed, and white areas represent water.

- Mean NDVI (environmental productivity) is higher inside protected areas than it is outside protected areas across Canada.
- Variance is higher across central and mountainous regions of Canada, while coastal and Arctic regions had lower variance
- Variance within vs. outside of protected areas is not consistent across Canada; in some ecozones, variance is higher outside of protected areas (Atlantic Maritime), while in others it is higher inside protected areas (Arctic).
- The model was less stable at predicting NDVI in areas of higher elevation, indicating an area for further research.

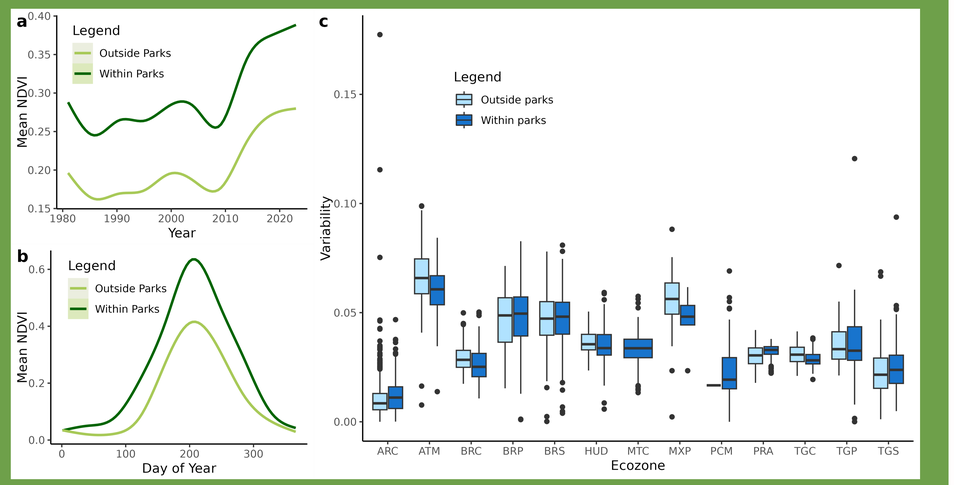

Figure 3: (a) Trends in predicted NDVI within and outside protected areas (parks) between 1980 and 2023. (b) Trends in predicted NDVI within and outside protected areas (parks) in a yearly cycle, given by day of year. (c) Trends in variance of residuals within and outside protected areas (parks) by ecozone, where the box represents the mean and inter-quartile range of values, and black dots represent outlier points.

Conclusion

In order to ensure we are protecting high quality ecosystems for species survival, we need to consider environmental stability and variability when designating protected areas. Using our methodology, it is possible to calculate the variance around mean environmental conditions for any region. Currently protected areas in Canada are more vulnerable to extreme weather events and changing conditions. Our research is an essential next step to improving protected area designations worldwide.

References

Field, C. B., Barros, V., Stocker, T. F., Dahe, Q., Dokken, D. J., Plattner, G.-K., Ebi, K. L., Allen, S. K., Mastandrea, M. D., Tignor, M., Mach, K. J., & Midgeley, P. M. (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.

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All the code used to acquire + analyse data as well as create the subsequent figures is available via GitHub

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Quantitative Ecology Lab UBC Okanagan