

SDM AFFECTED BY POSITIONAL UNCERTAINTY IN SPECIES OCCURRENCES CAN STILL BE ECOLOGICALLY INTERPRETABLE

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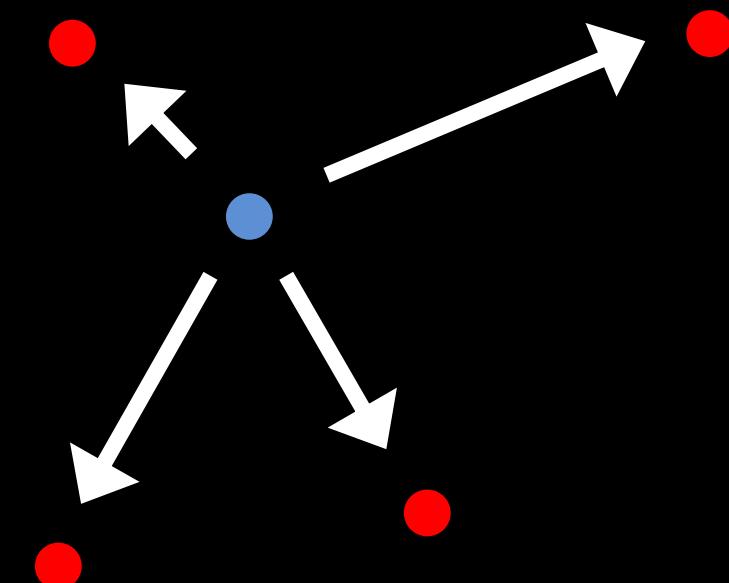
POSITIONAL UNCERTAINTY

The negative influence of positional uncertainty in spatial modeling is a long-known fact.

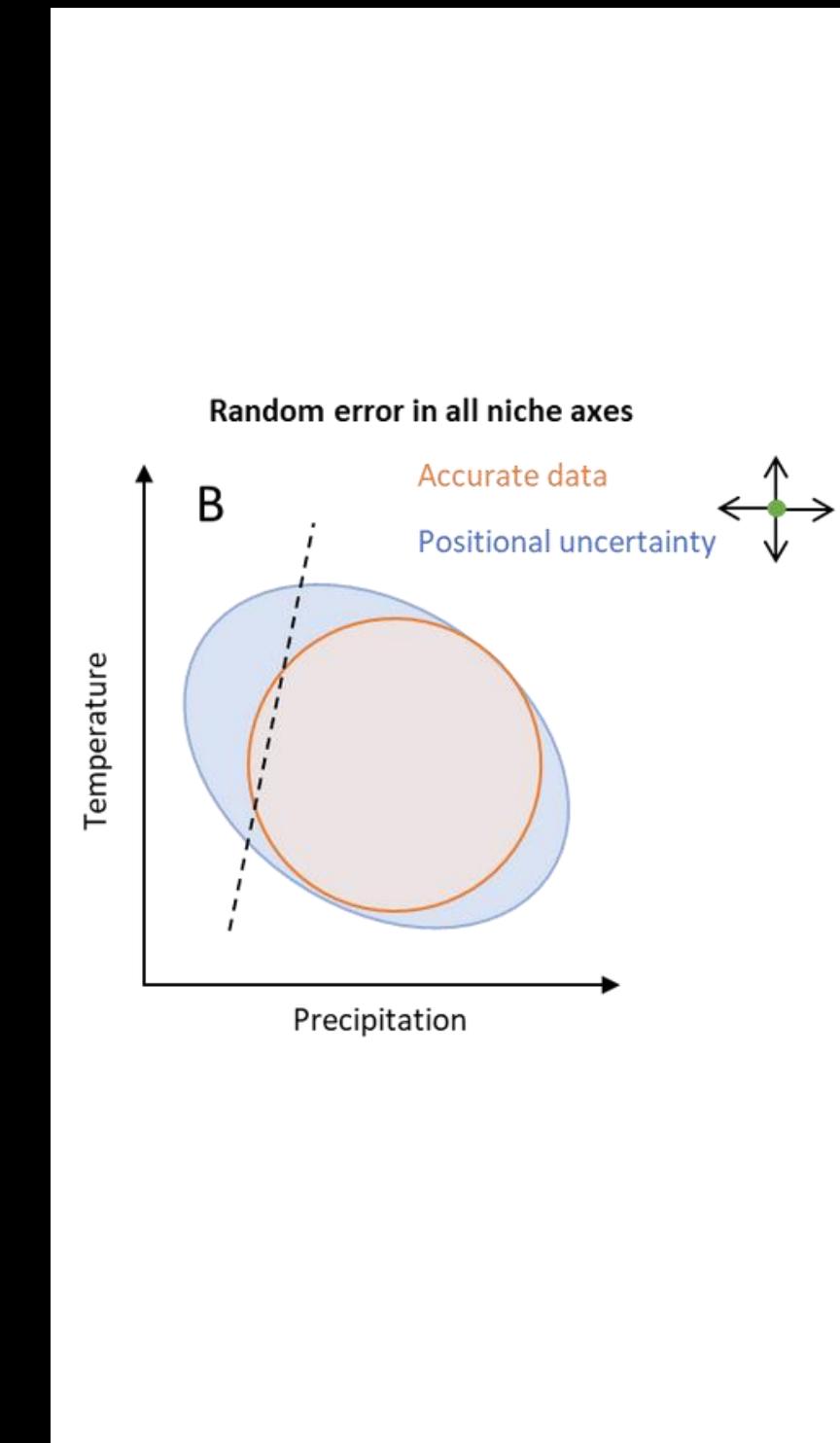
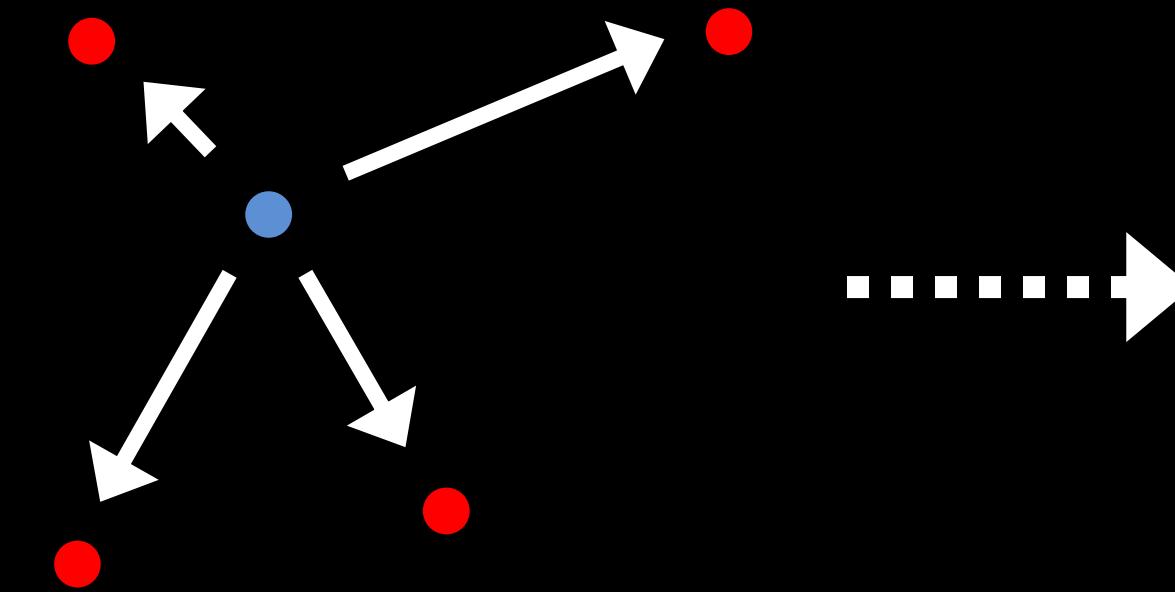
With an increasing number of ecological studies using spatial modeling tools, it became important to find out how limiting positional uncertainty in species occurrences could be.

That started among ecologists a long-lasting debate whether species occurrences with positional error are useful or not.

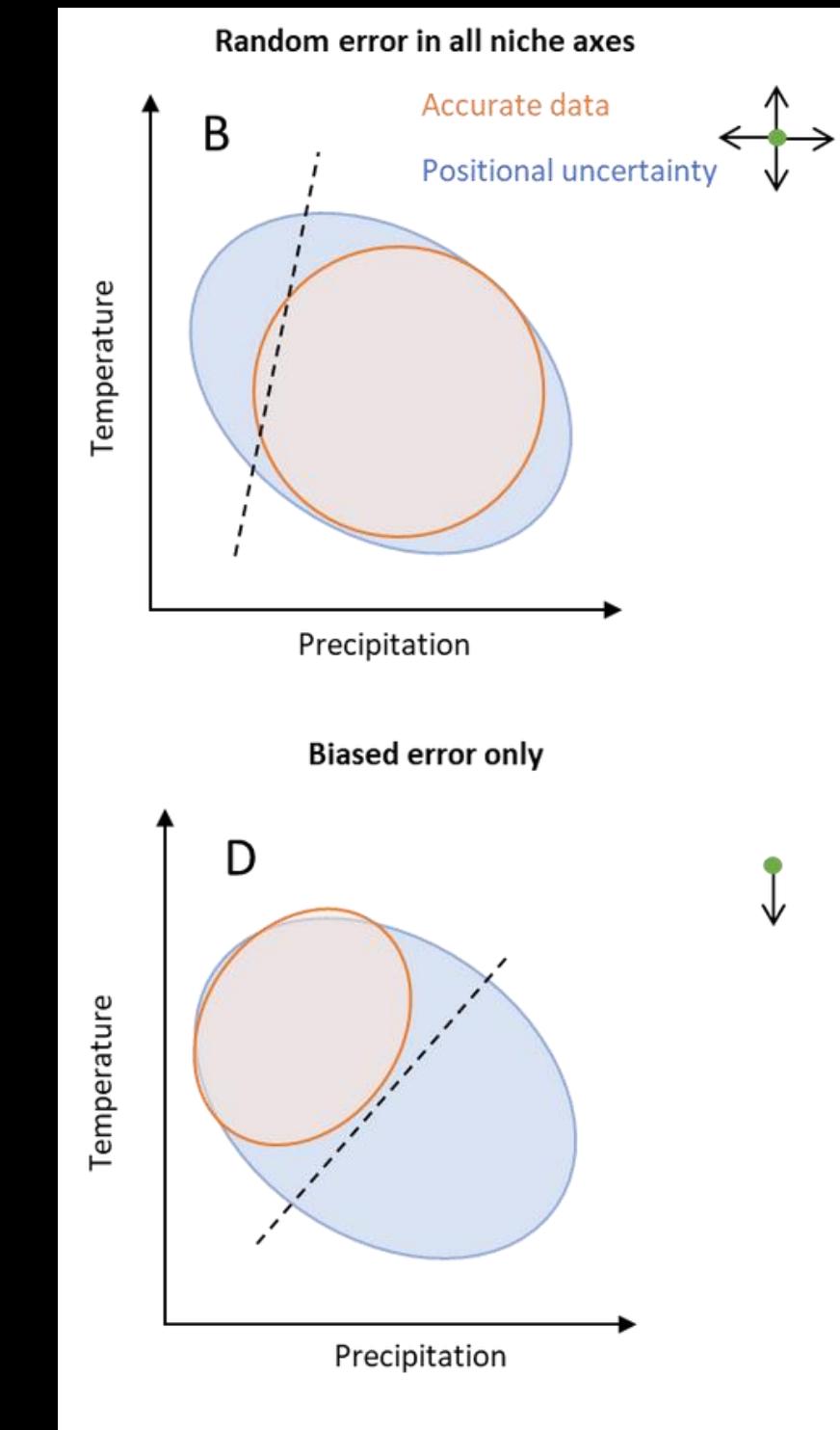
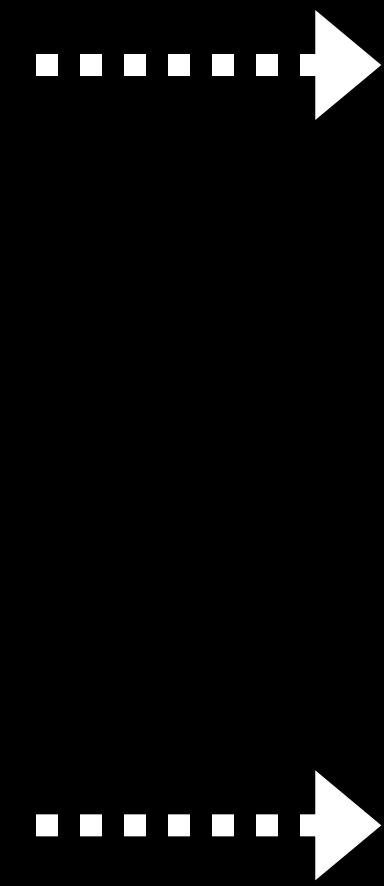
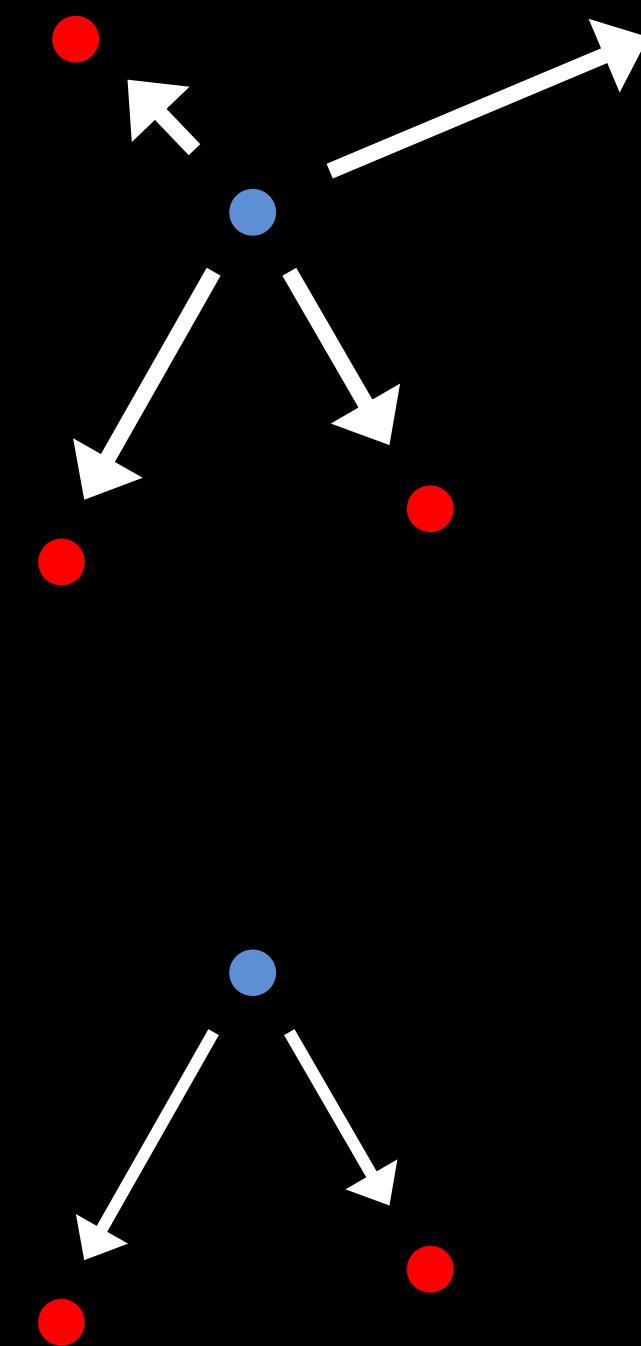
THE EFFECT POSITIONAL UNCERTAINTY



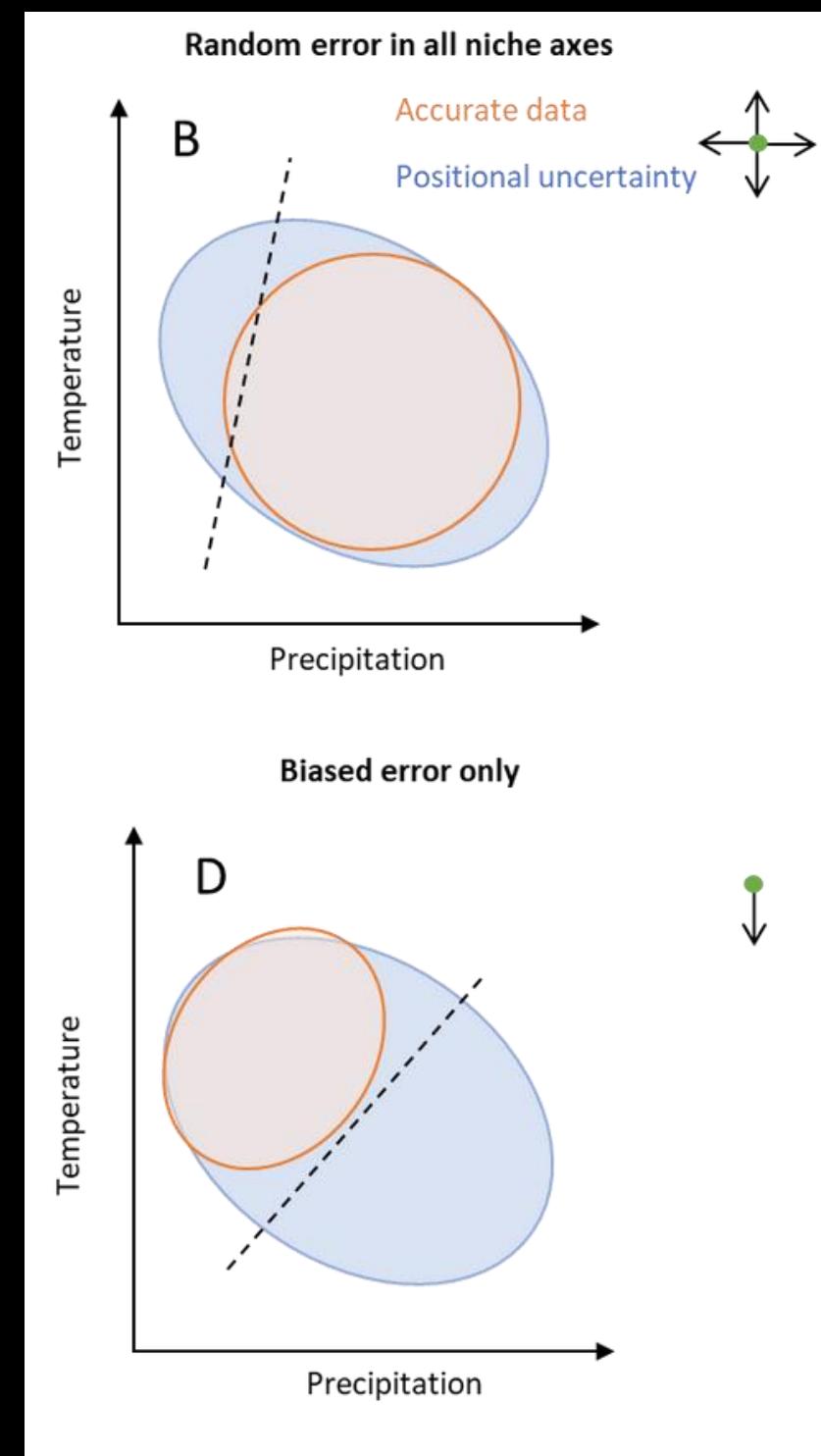
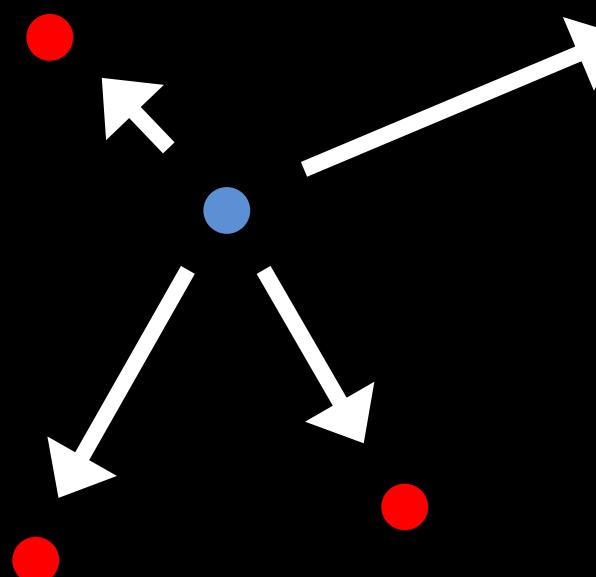
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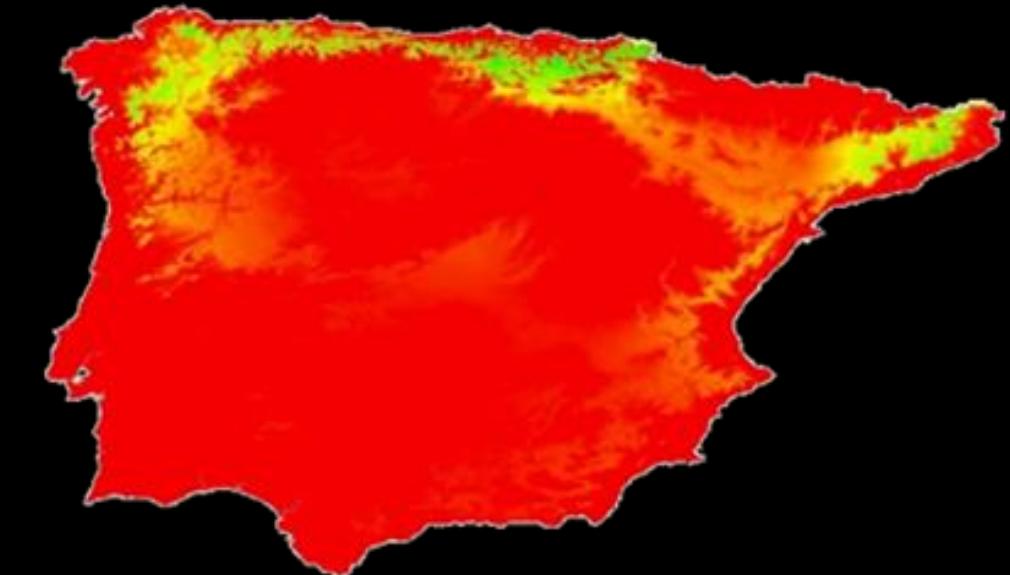
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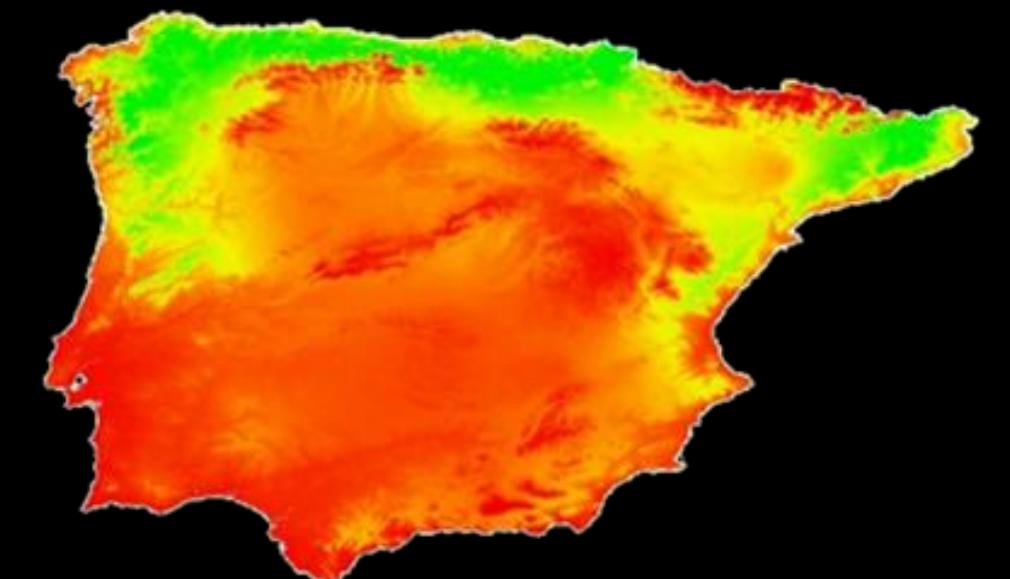
THE EFFECT POSITIONAL UNCERTAINTY



Accurate data – AUC 0.93



inaccurate data – AUC 0.78



WHAT HAVE WE LEARNT?

Few prior studies that concluded opposing results



WHAT HAVE WE LEARNT?

Prior studies concluded opposing results

Possible explanation offered Naimi et al. (2014)

Heterogeneous predictor



Homogeneous predictor

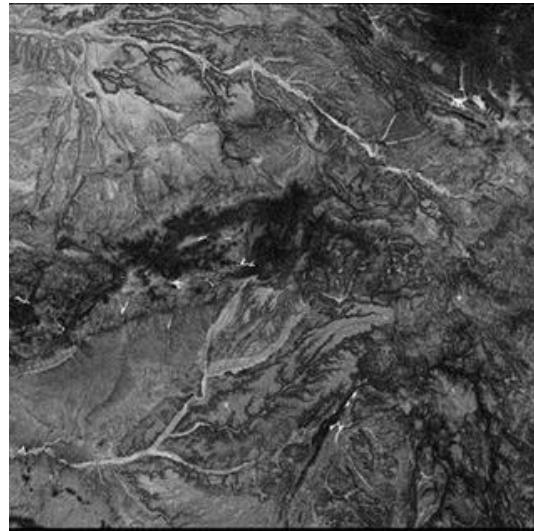


X

WHAT HAVE WE LEARNT?

Prior studies concluded opposing results

Possible explanation offered Naimi et al. (2014) and Gábor et al. (2020)

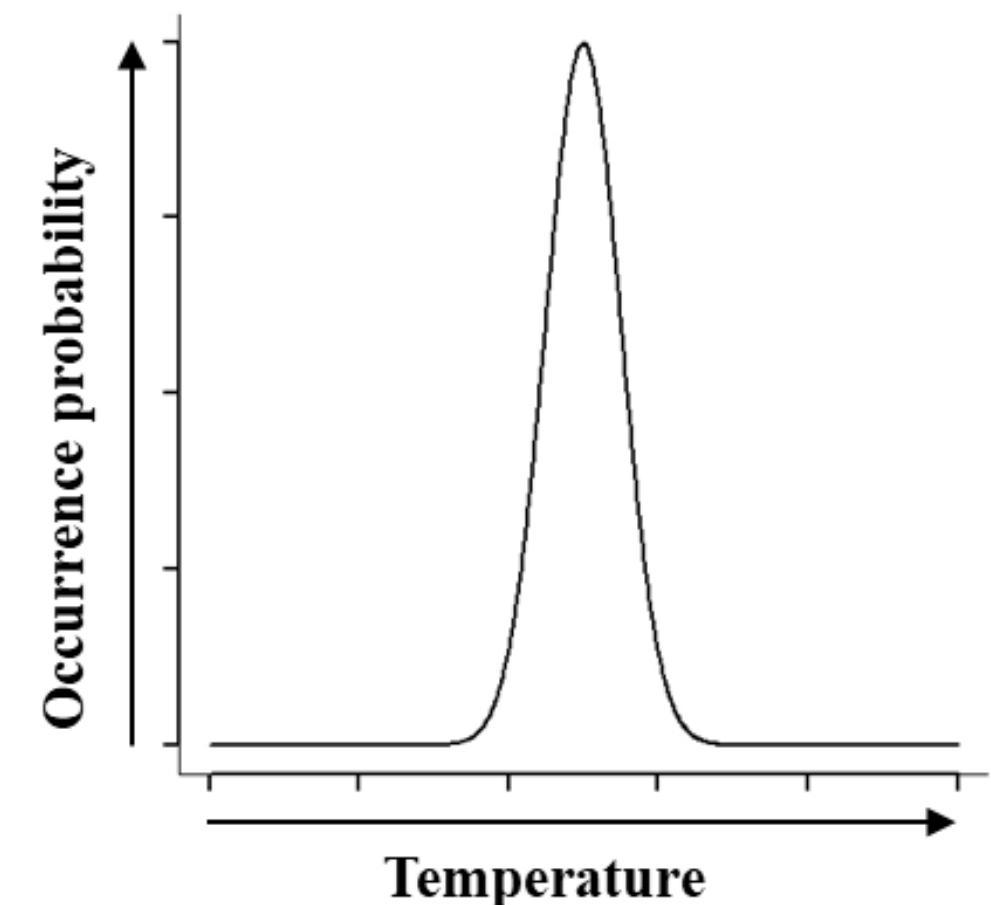


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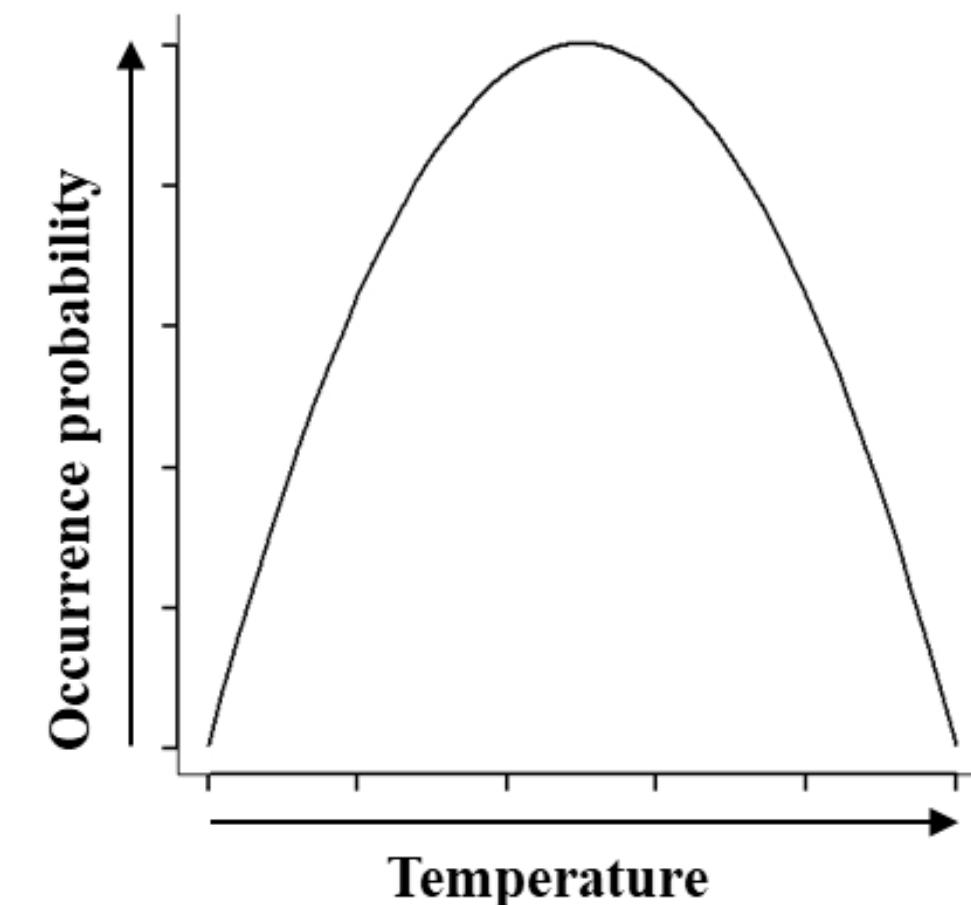


Wide niche breadth

Narrow niche breadth

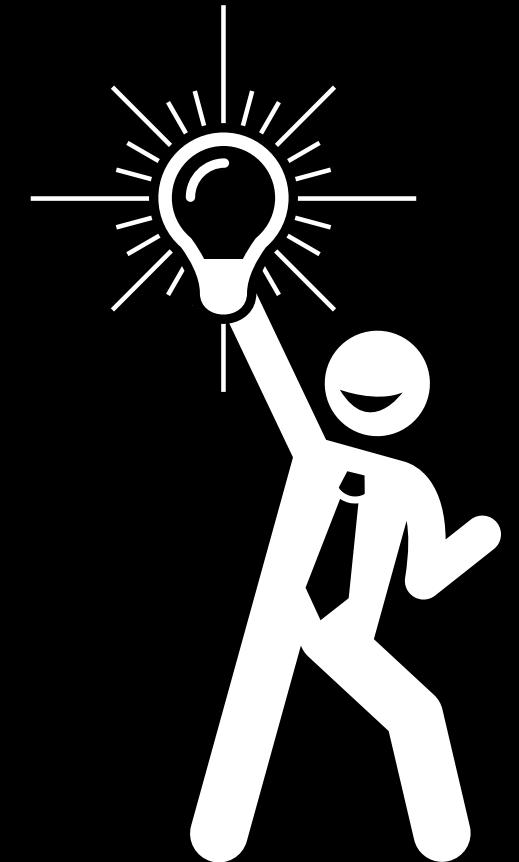


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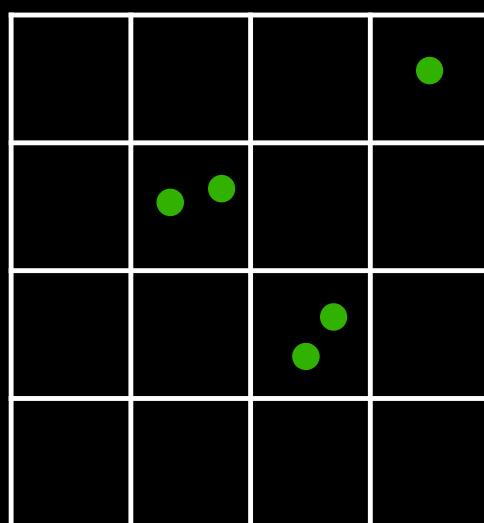
Temperature

**ARE WE ABLE TO OVERCOME THE NEGATIVE EFFECT
OF POSITIONAL UNCERTAINTY?**

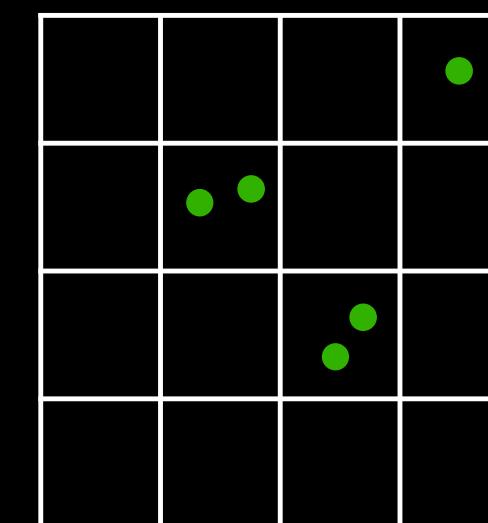


ARE WE ABLE TO OVERCOME THE NEGATIVE EFFECT OF POSITIONAL UNCERTAINTY?

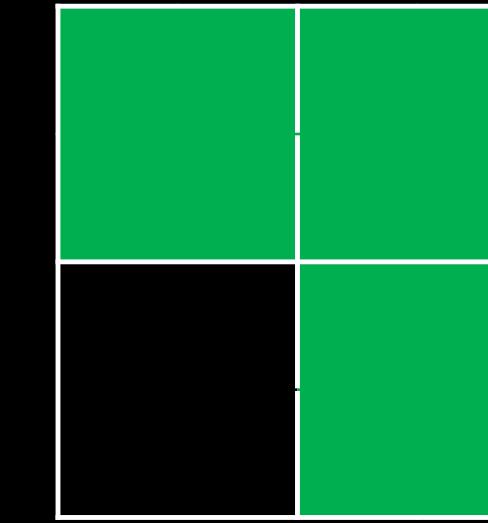
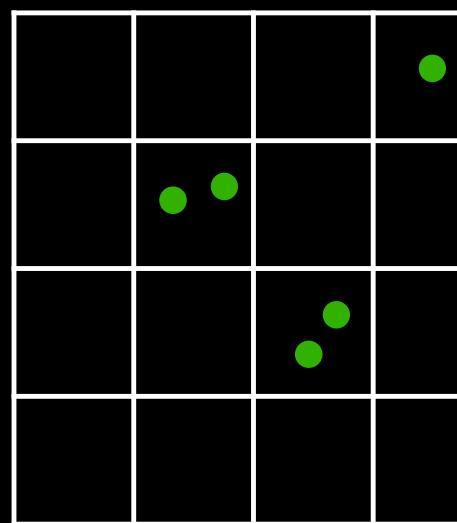
Remove unprecise occurrences



Increase number of occurrences

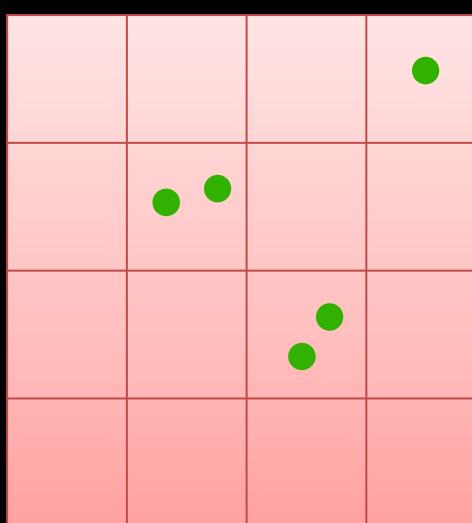


Coarsen the analysis grain



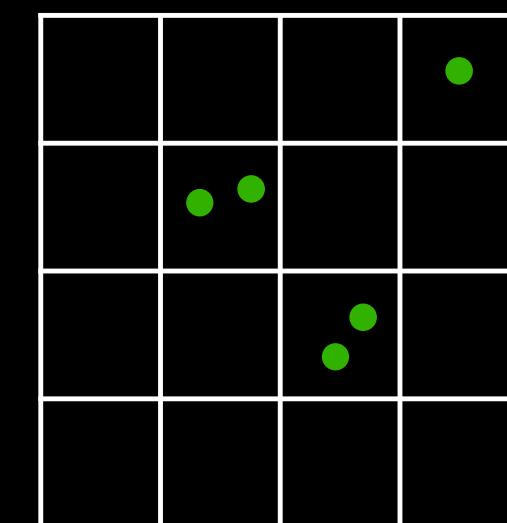
ARE WE ABLE TO OVERCOME THE NEGATIVE EFFECT OF POSITIONAL UNCERTAINTY?

Remove unprecise occurrences

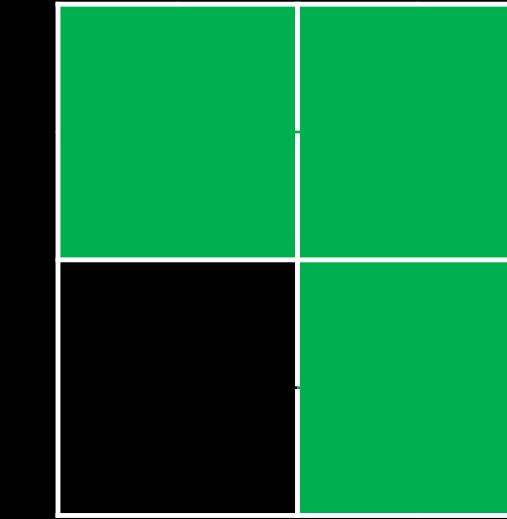
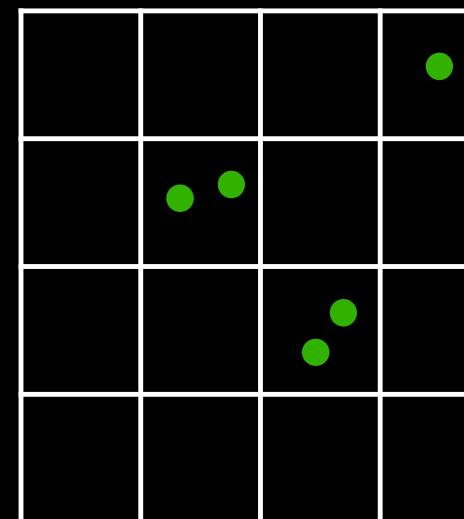


Merow et al. 2014
Smith et al. 2021

Increase number of occurrences

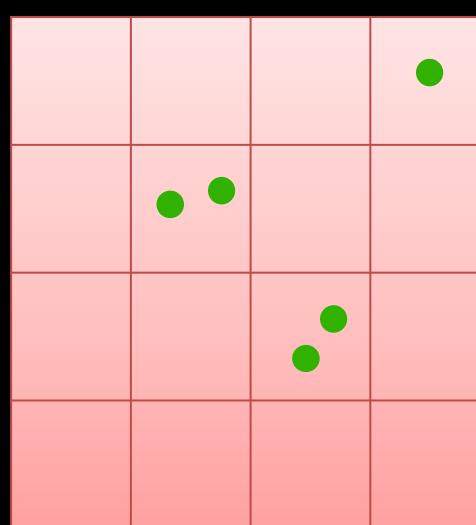


Coarsen the analysis grain



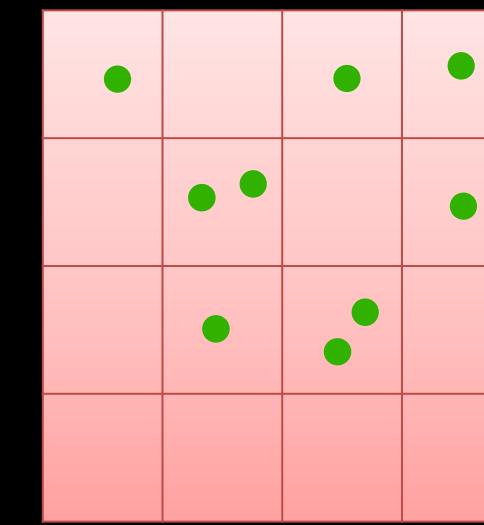
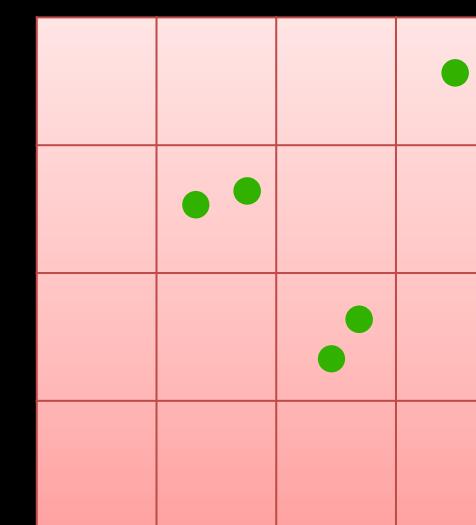
ARE WE ABLE TO OVERCOME THE NEGATIVE EFFECT OF POSITIONAL UNCERTAINTY?

Remove unprecise occurrences



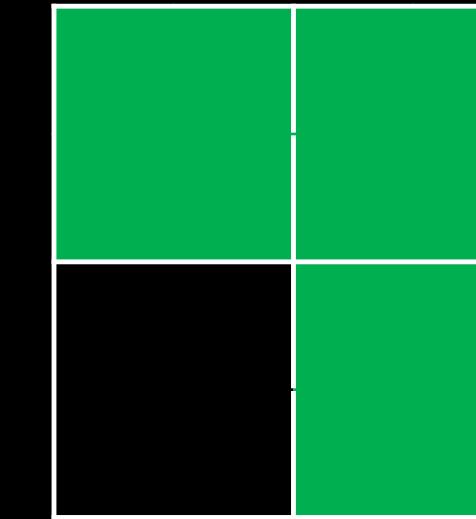
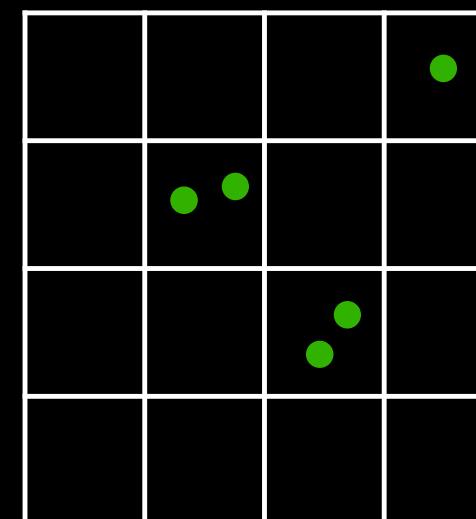
Merow et al. 2014
Smith et al. 2021

Increase number of occurrences



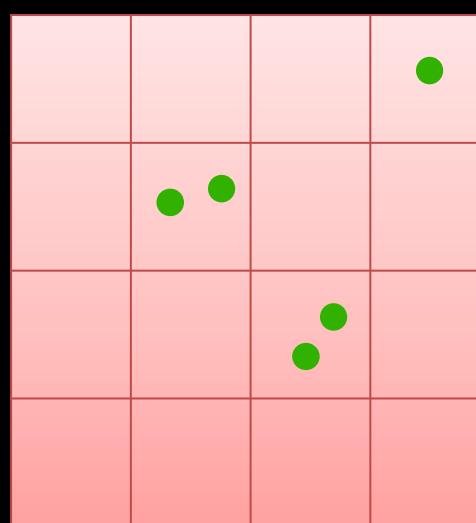
Reside et al. 2011
Gábor et al. 2020

Coarsen the analysis grain



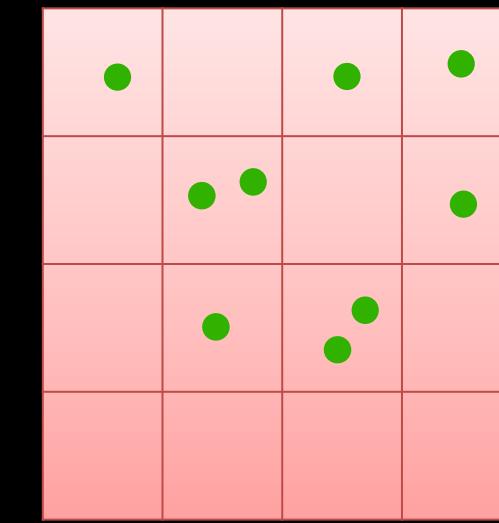
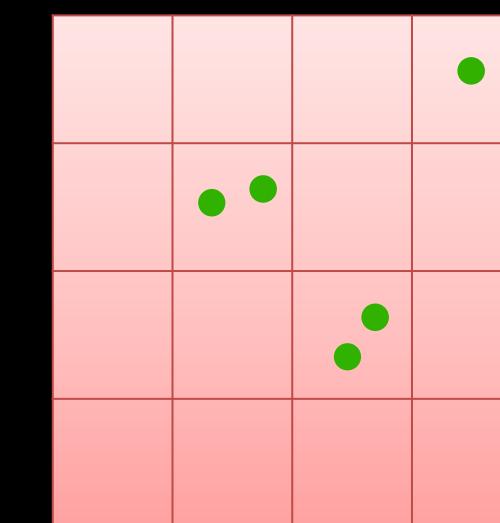
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Remove unprecise occurrences



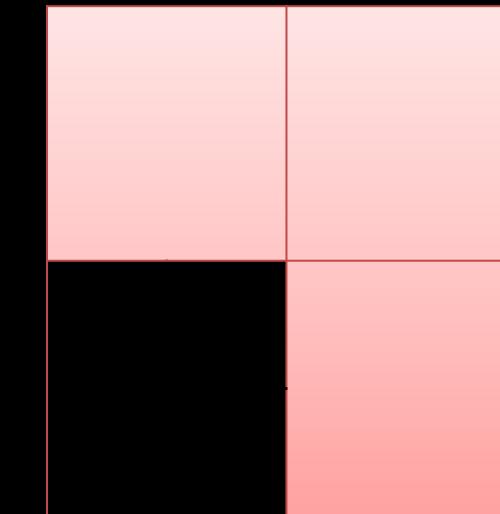
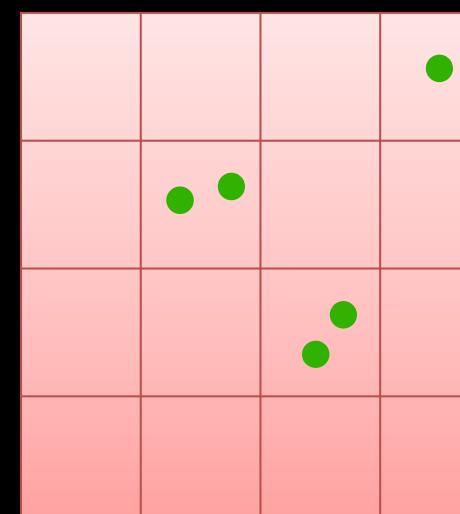
Merow et al. 2014
Smith et al. 2021

Increase number of occurrences



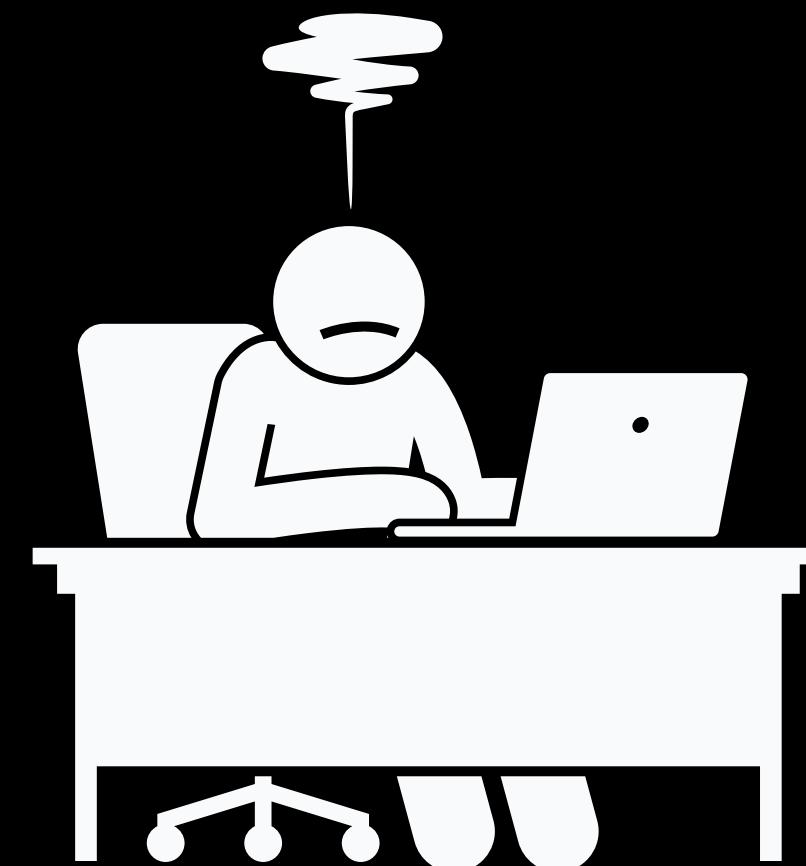
Reside et al. 2011
Gábor et al. 2020

Coarsen the analysis grain



Gábor et al. 2022
(minor review MEE)

ARE WE AT A DEAD END?



I DO NOT THINK SO...

RESEARCH GAP

Although prior studies confirmed the effect of positional uncertainty on the model predictive performance

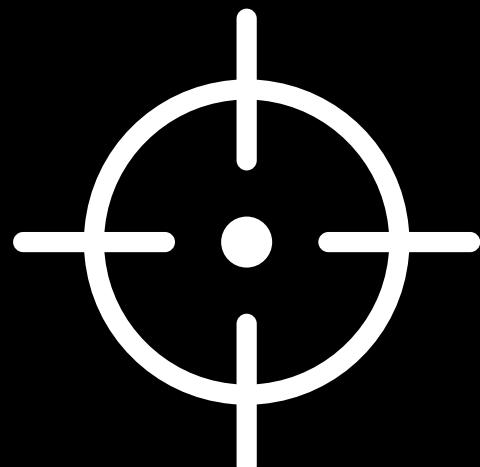
The question about how is the models' parameter estimation (species-environment relationships inference) remain largely unexplored.



STUDY AIM

To explore the extent to which parameter estimation is affected by positional uncertainty.

Specifically, to investigate the influence of positional error on variable importance and the shape of the response curves.



DATA



Species	Cantabrian brown bear
Latin name	<i>Ursus arctos pyrenaicus</i>
Number of occurrences	112
Study area	Spain (except islands)
Area	492 423 km ²
Modeling resolution	50 x 50 m

5 environmental variables



Species	Band-tailed Pigeon
Latin name	<i>Patagioenas fasciata</i>
Number of occurrences	111
Study area	USA (except Alaska and Hawaii)
Area	8 081 863 km ²
Modeling resolution	1 x 1 km

10 environmental variables

METHODS

Simulated positional uncertainty (six different scenarios)

R package sdm

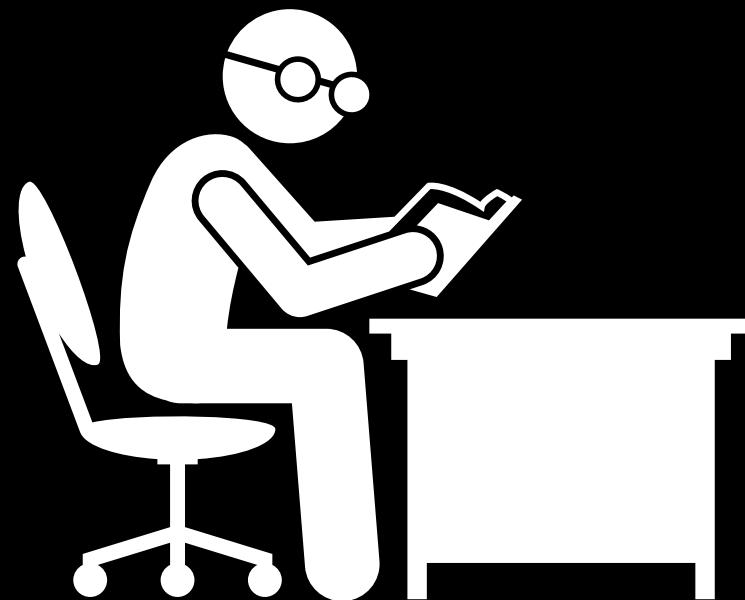
MaxEnt modeling method

Evaluated model predictive performance

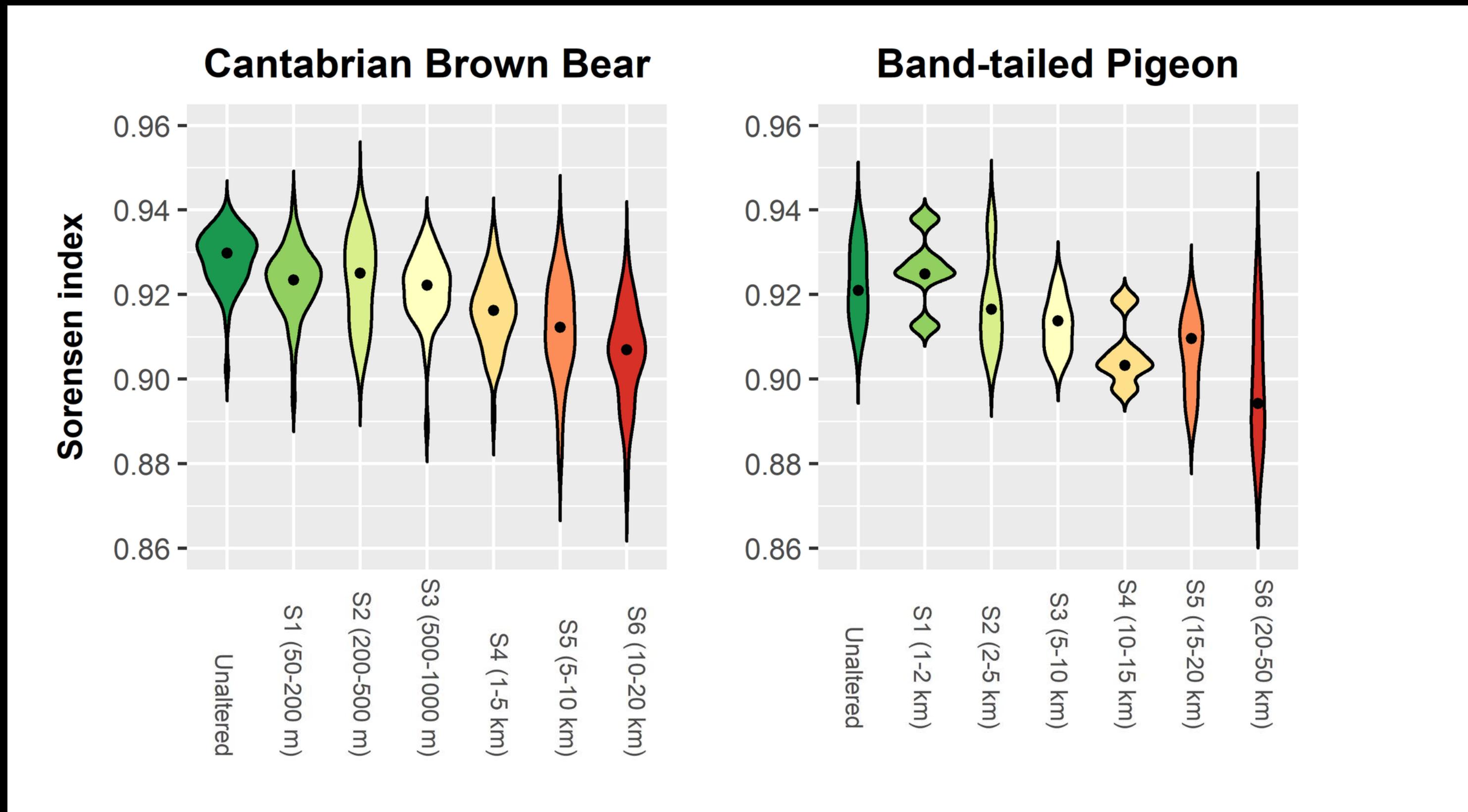
Evaluated each predictor's variable importance

Visualized predicted responses to the environmental variables

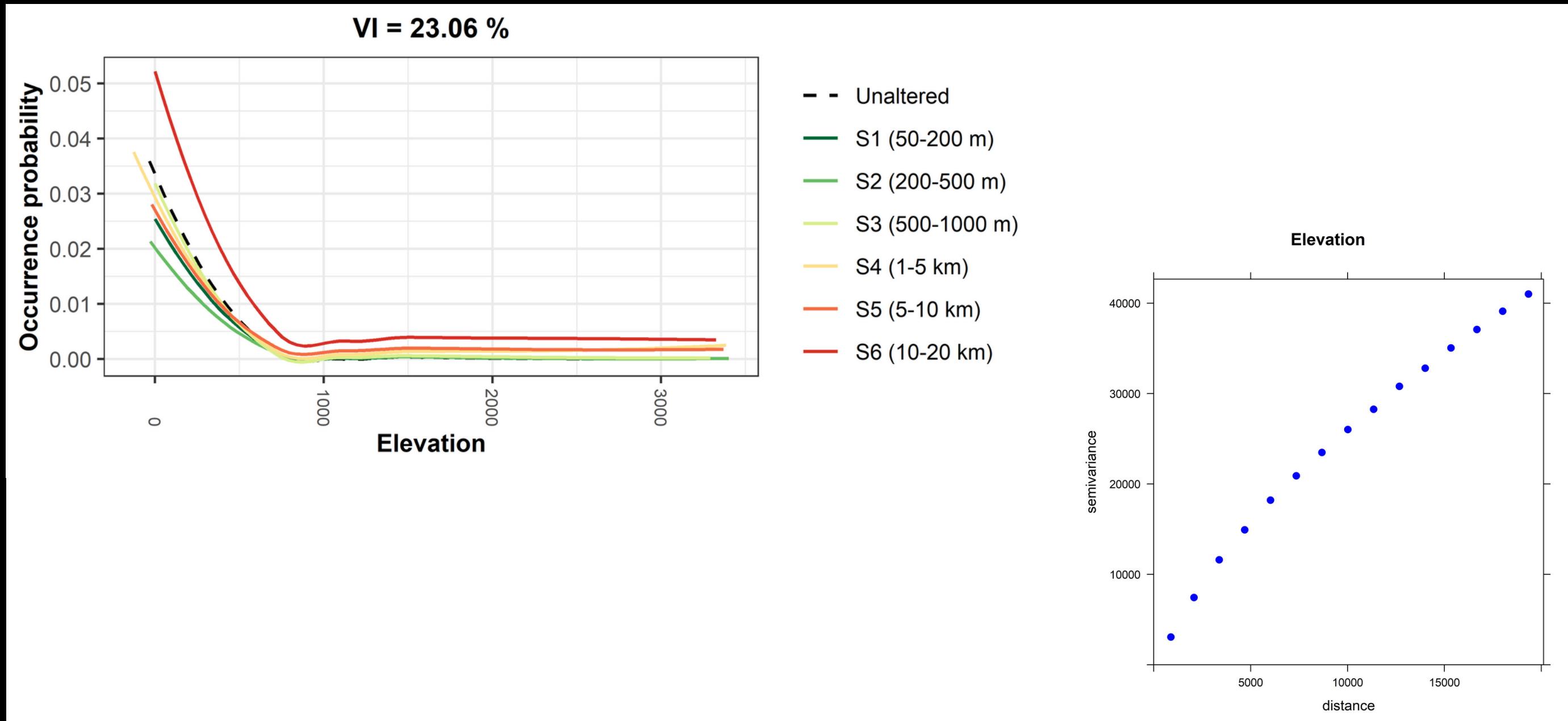
Repeated each experiment 50 times



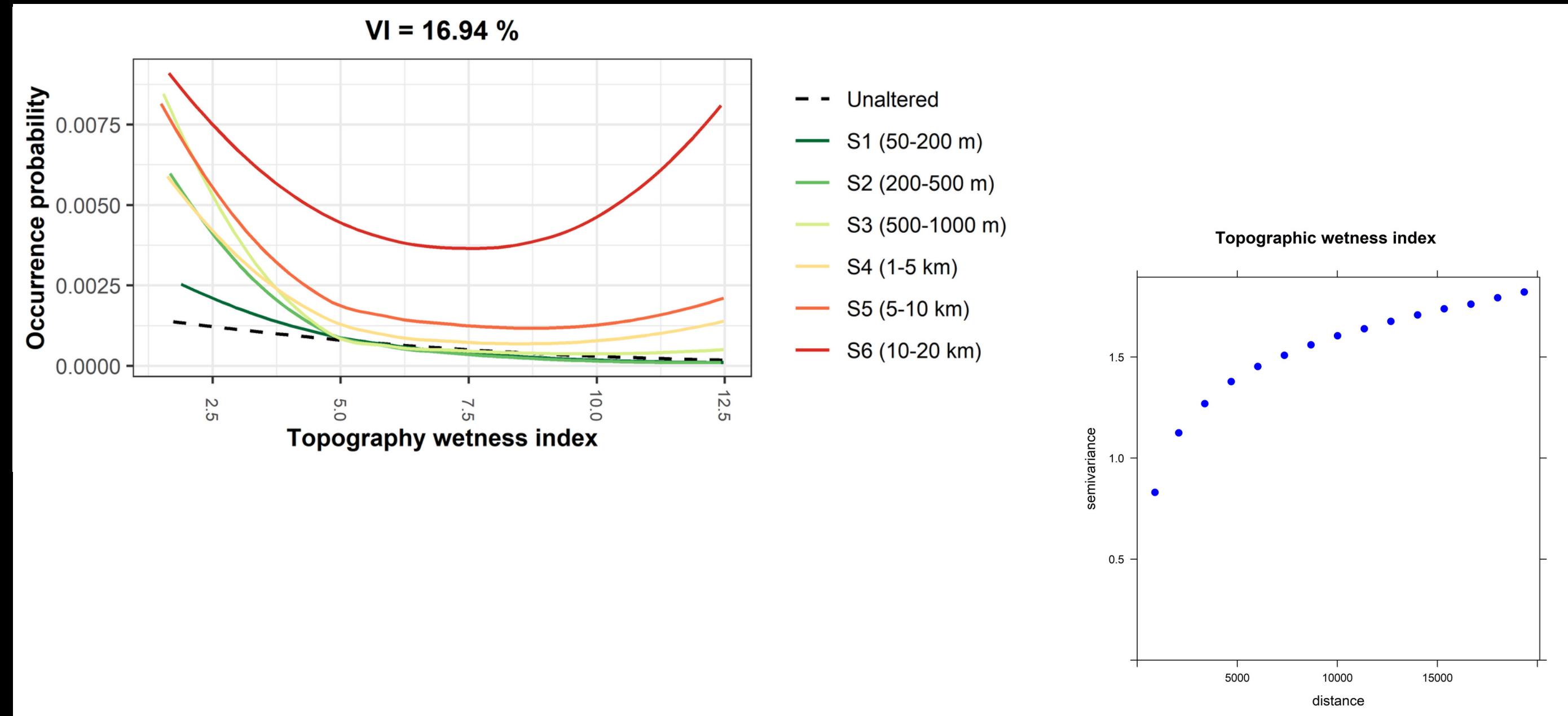
RESULTS - PREDICTIVE PERFORMANCE



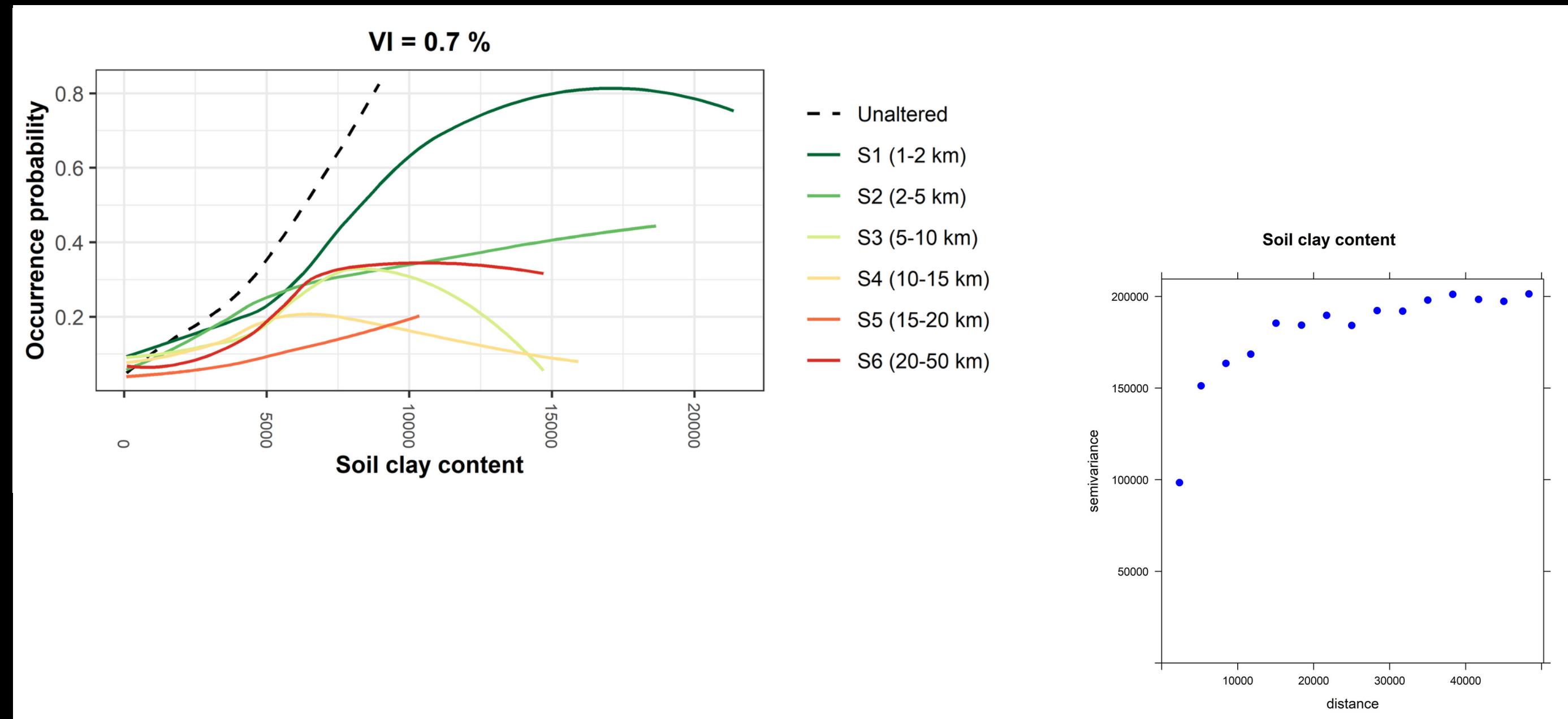
RESULTS - RESPONSE CURVES (CANTABRIAN BROWN BEAR)



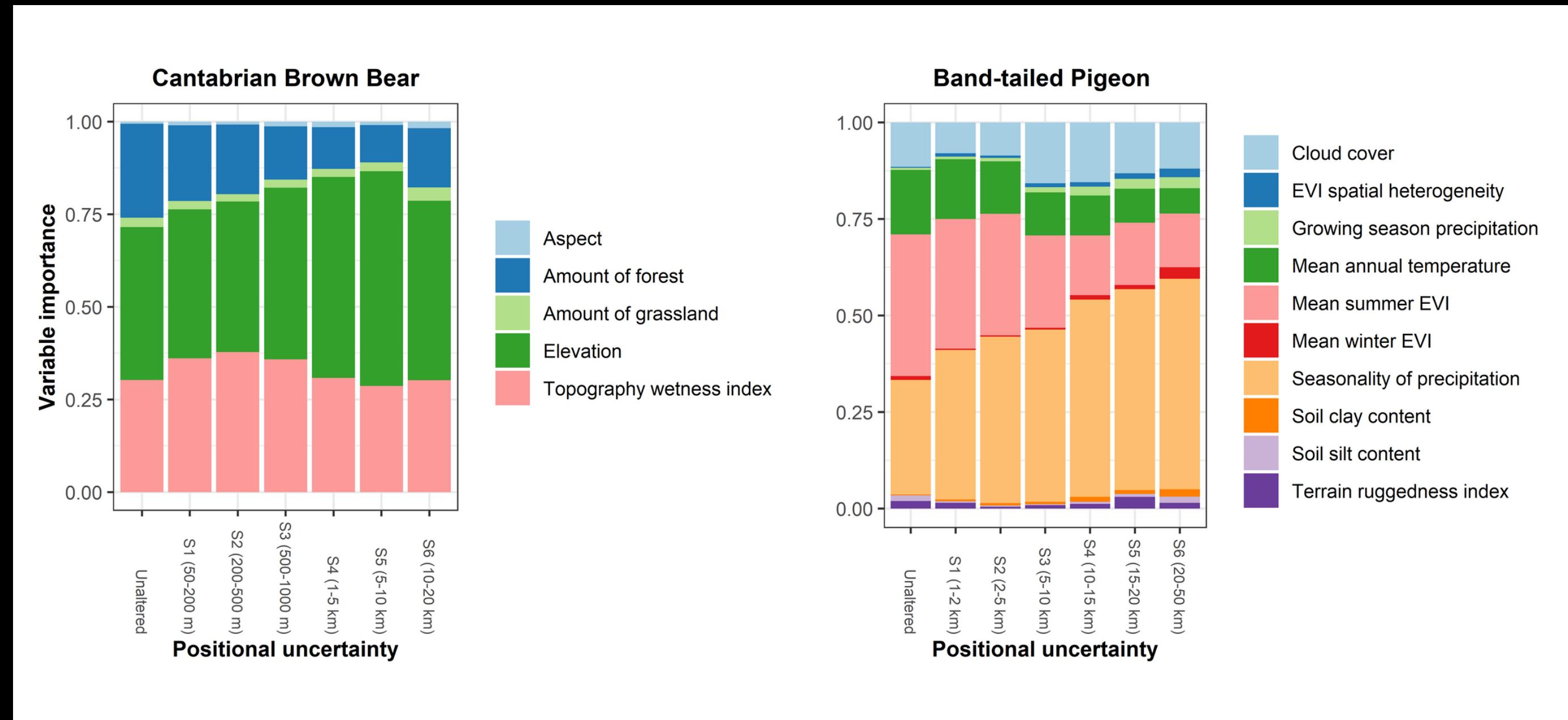
RESULTS - RESPONSE CURVES (CANTABRIAN BROWN BEAR)



RESULTS - RESPONSE CURVES (BAND-TAILED PIGEON)



RESULTS - VARIABLE IMPORTANCE



CONCLUSIONS

The negative consequences of positional uncertainty on model performance did not extend as strongly to the ecological interpretability of the models.

The findings are preliminarily encouraging for practitioners using SDMs to reveal generative mechanisms based on spatially uncertain data.

Additional research is needed to consider further environmental variables, species, and occurrence data types more comprehensively.

Positional uncertainty

Positional uncertainty



Naimi et al. 2014

**Spatial
autocorrelation**

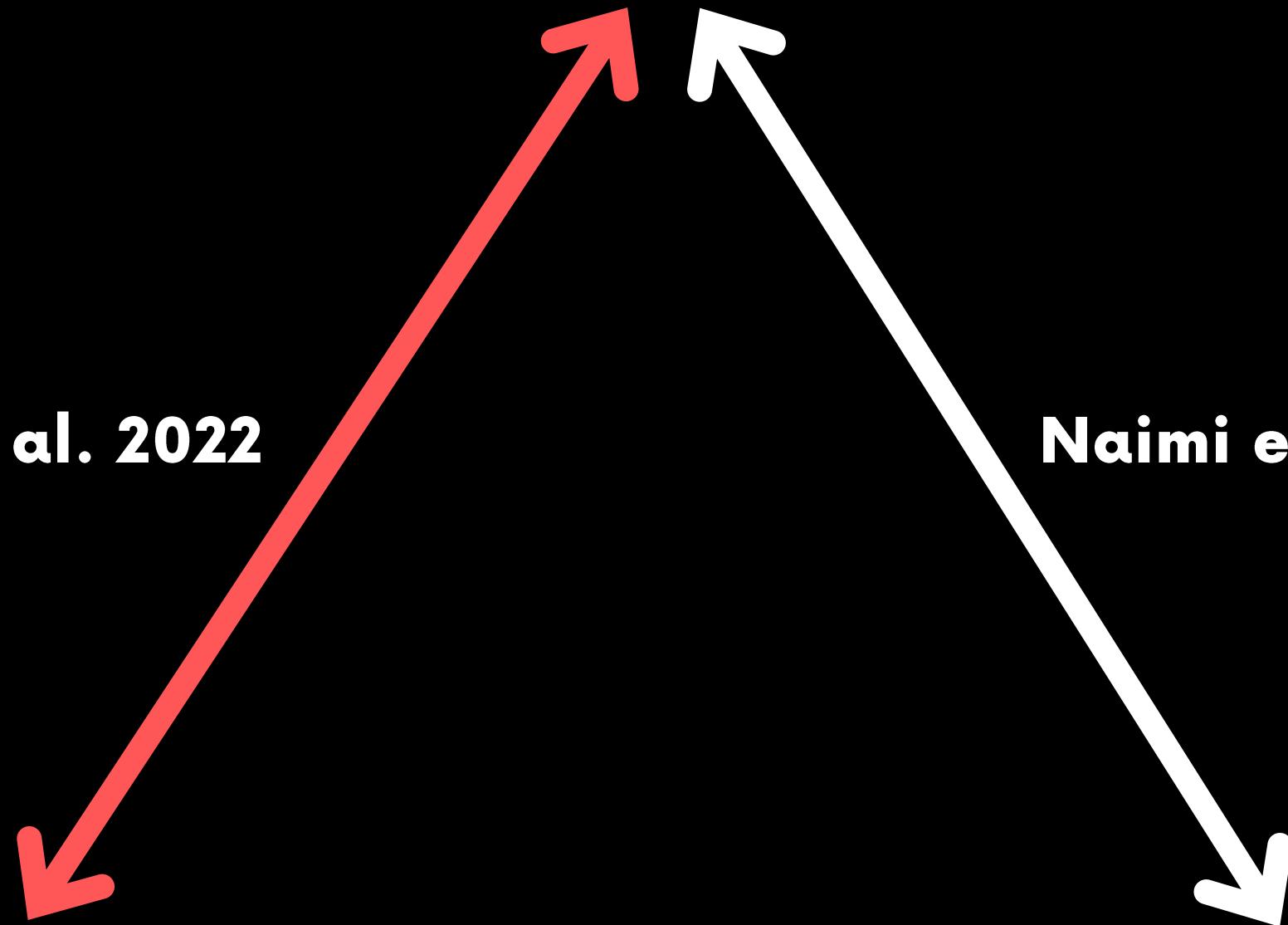
Positional uncertainty

Gábor et al. 2022

**Scale
Grain
Resolution**

Naimi et al. 2014

**Spatial
autocorrelation**



Positional uncertainty

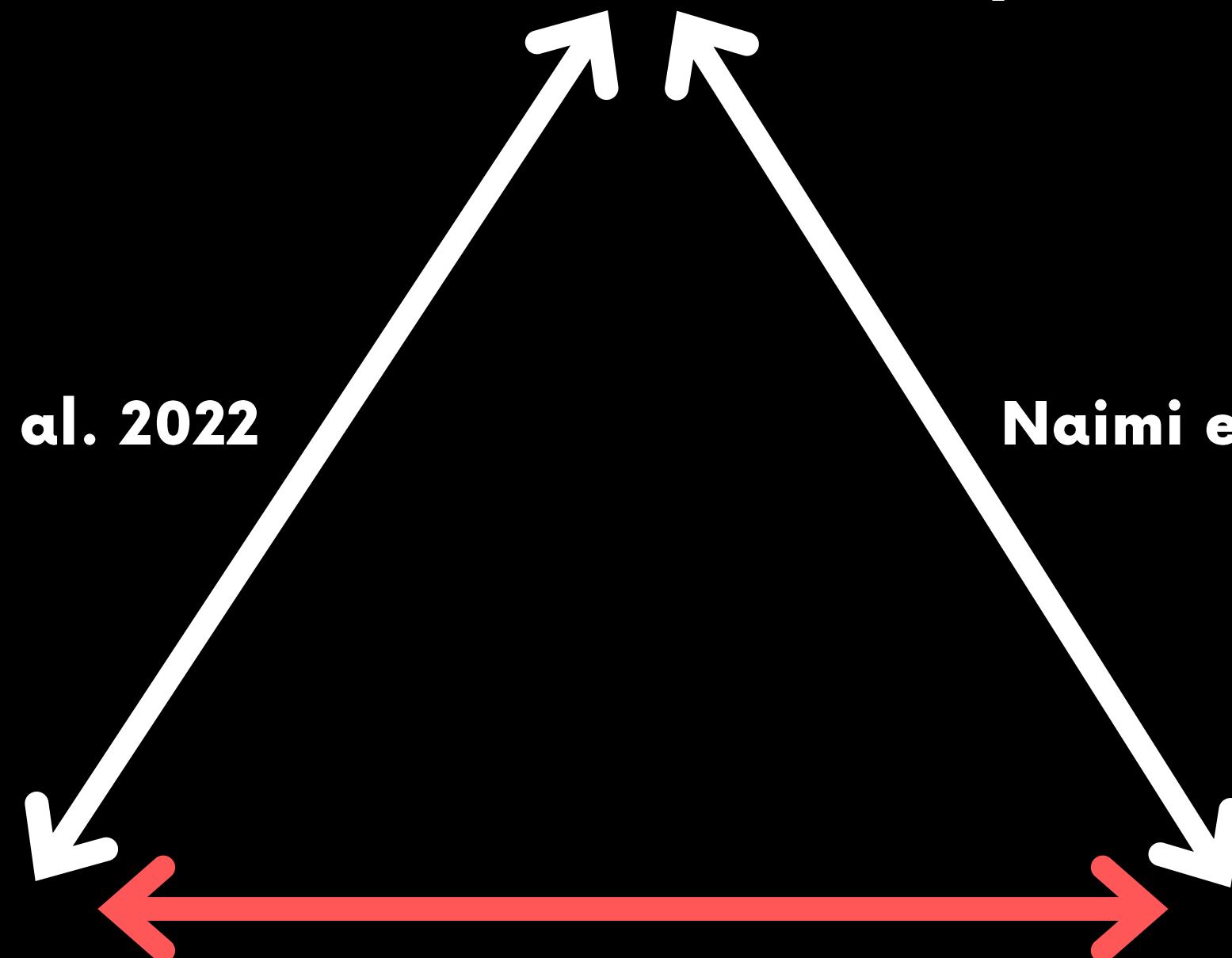
Gábor et al. 2022

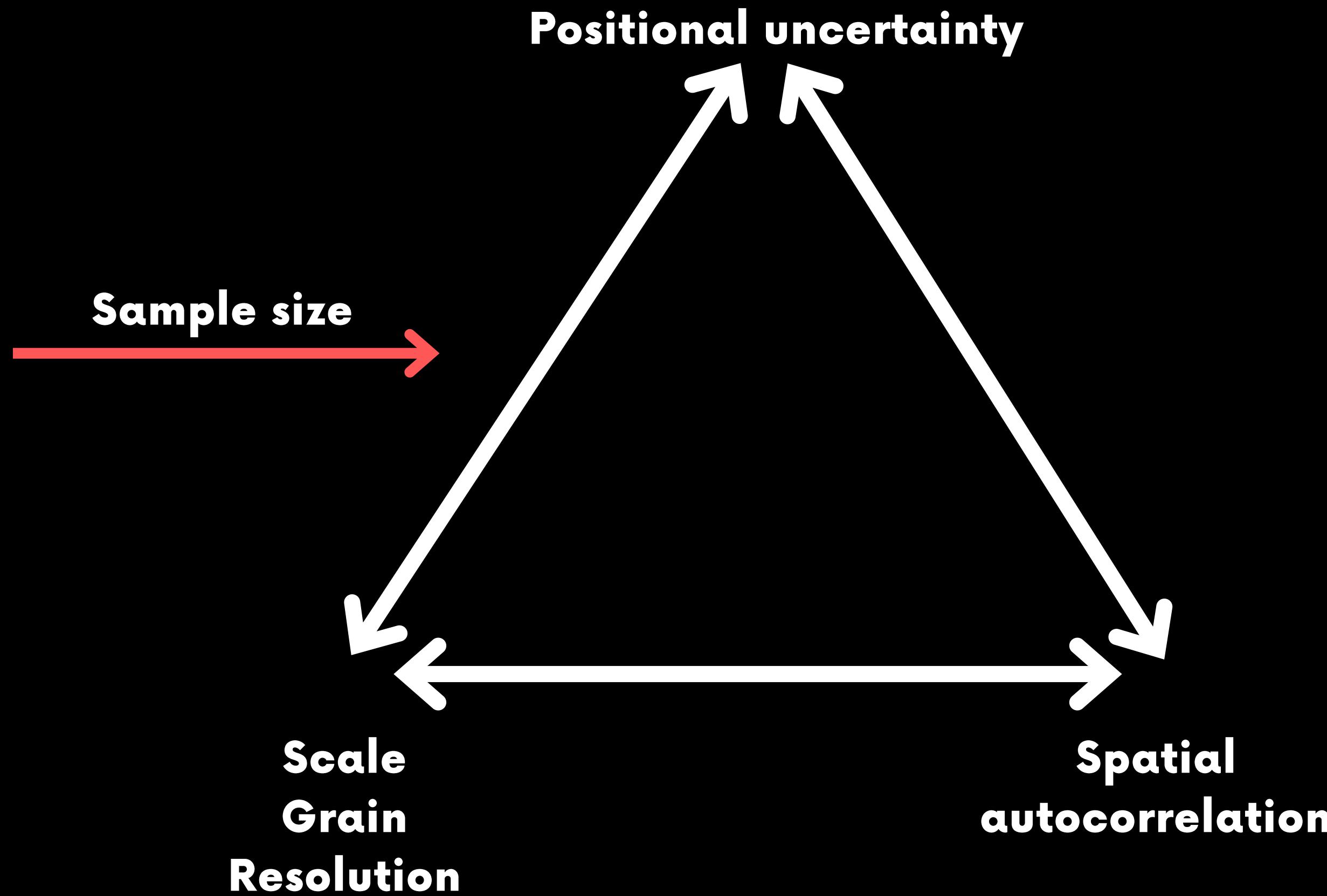
Naimi et al. 2014

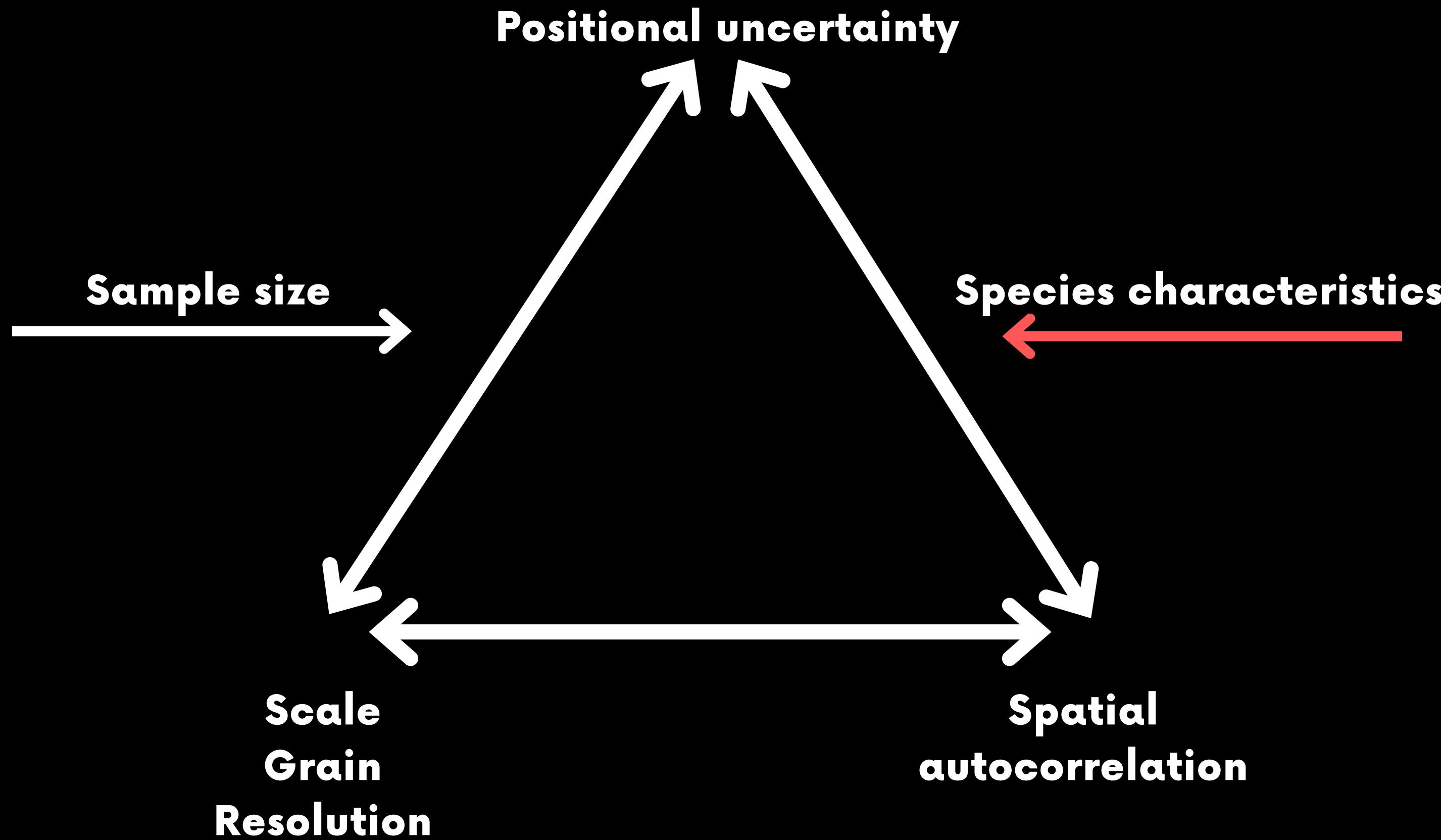
**Scale
Grain
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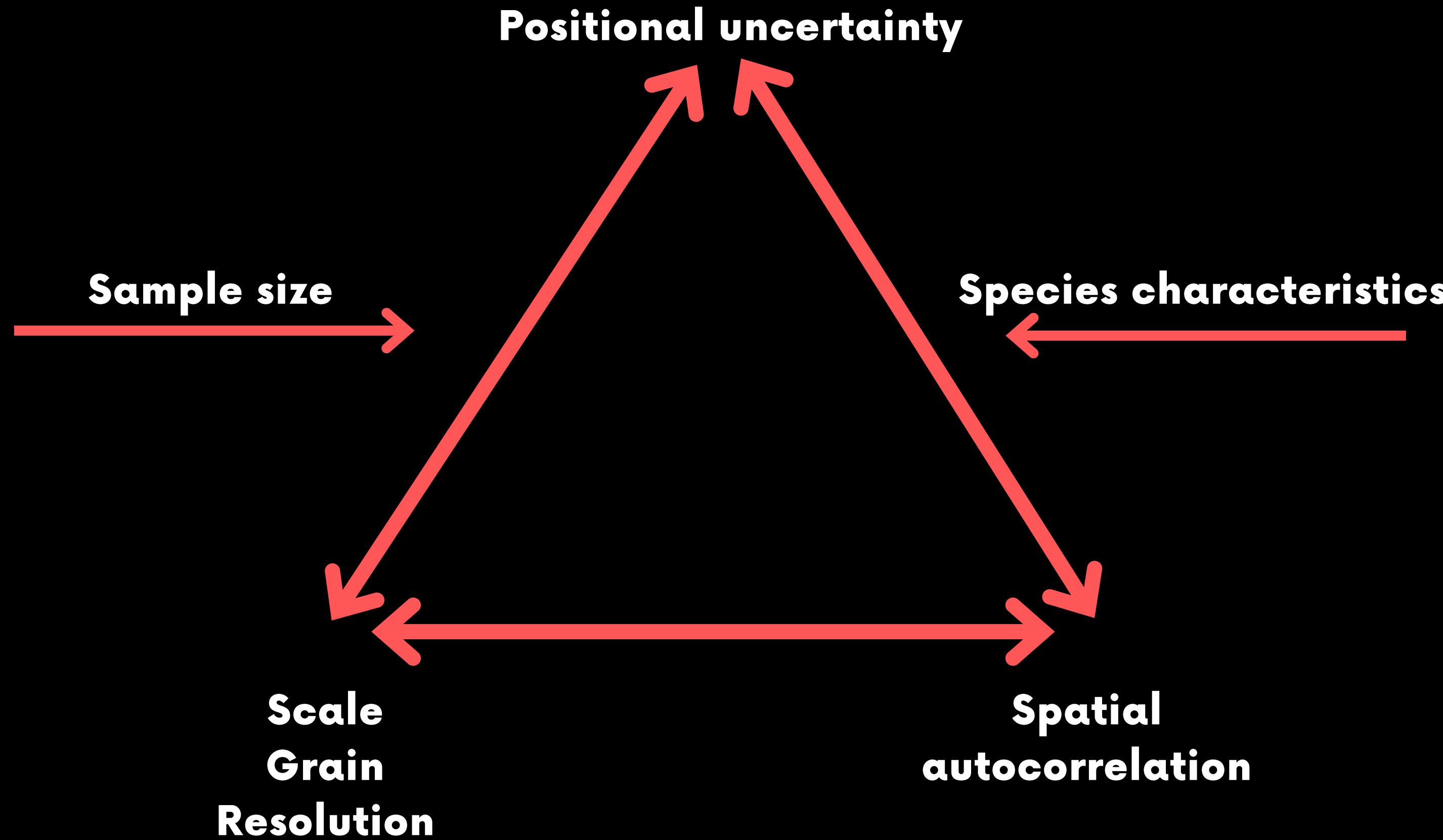
Mertes and Jetz 2018

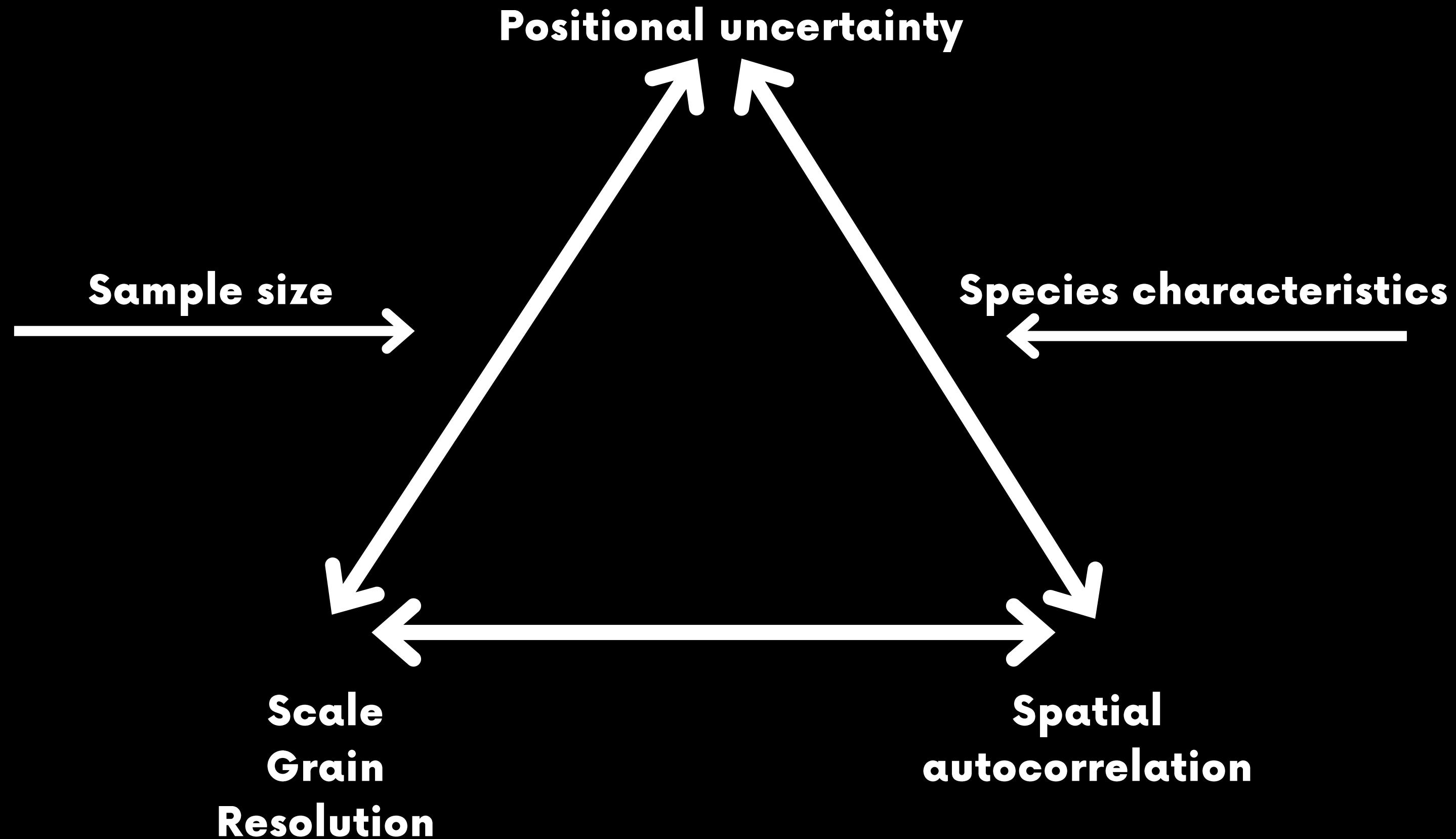
**Spatial
autocorrelation**







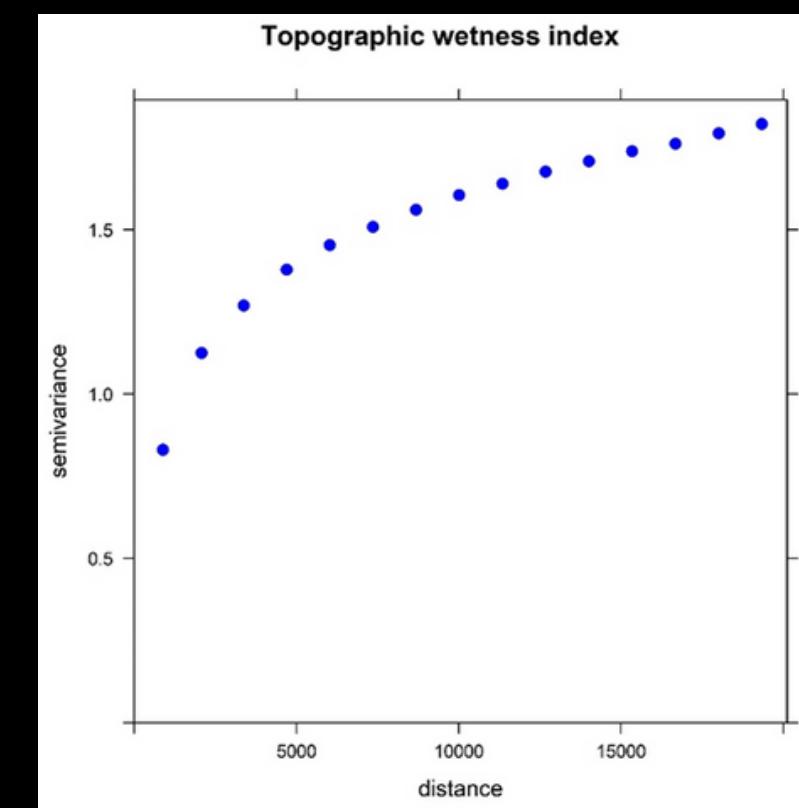
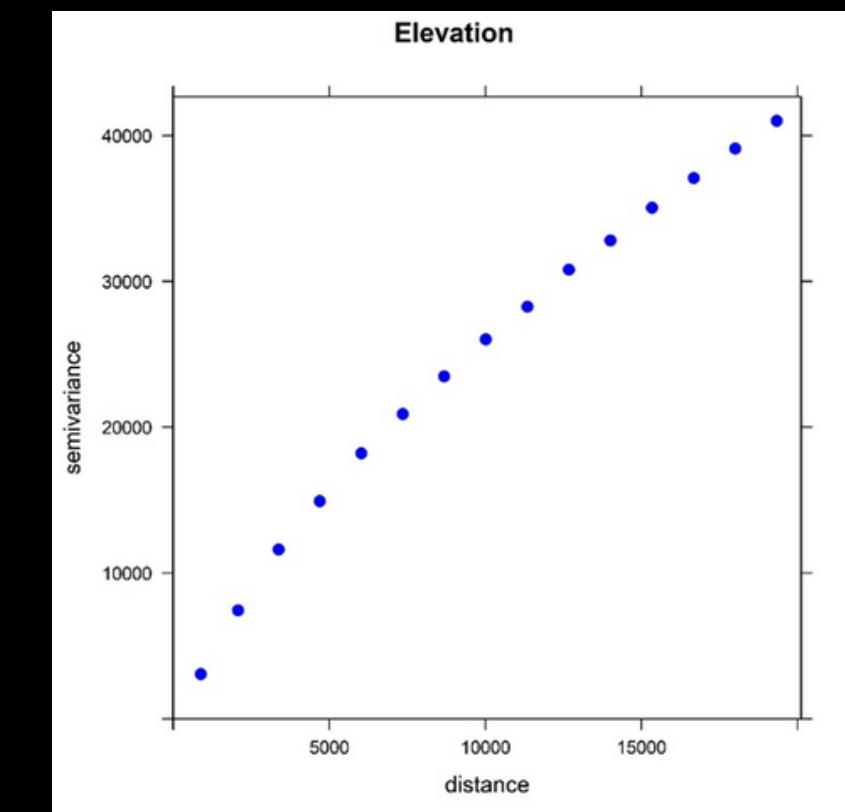
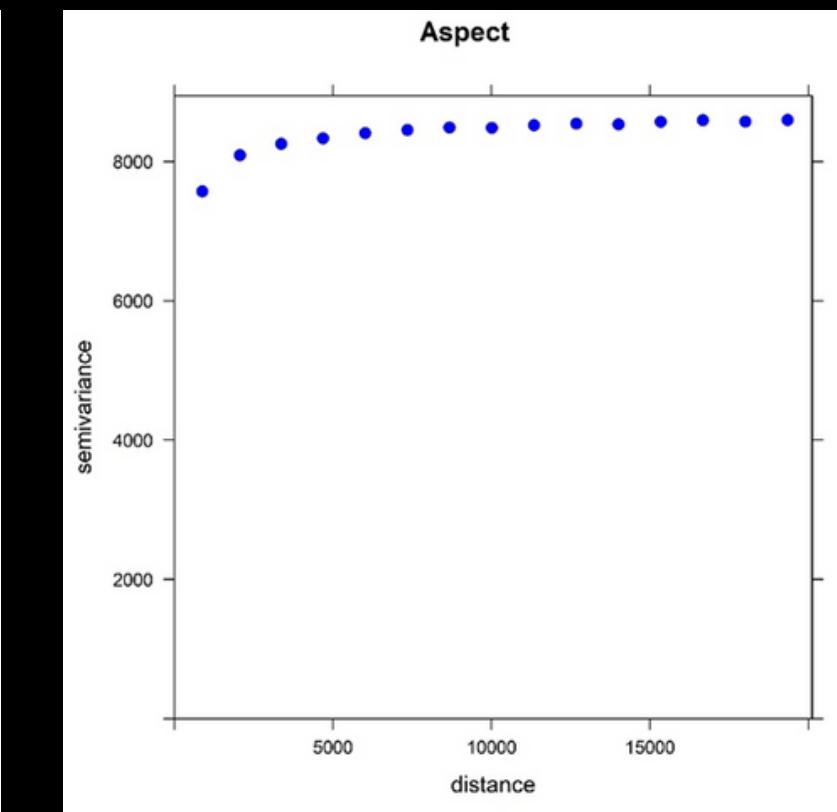
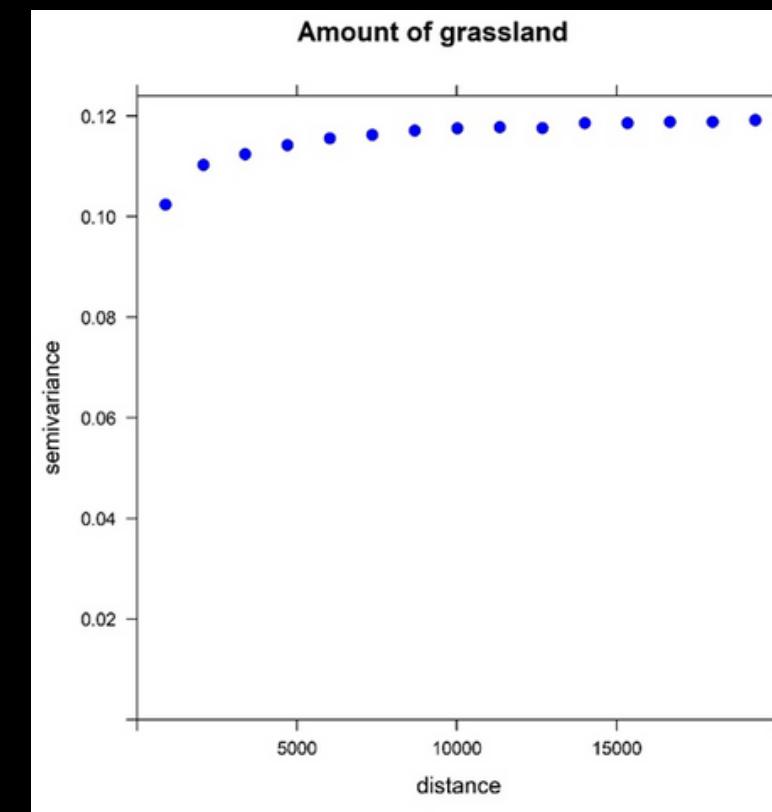
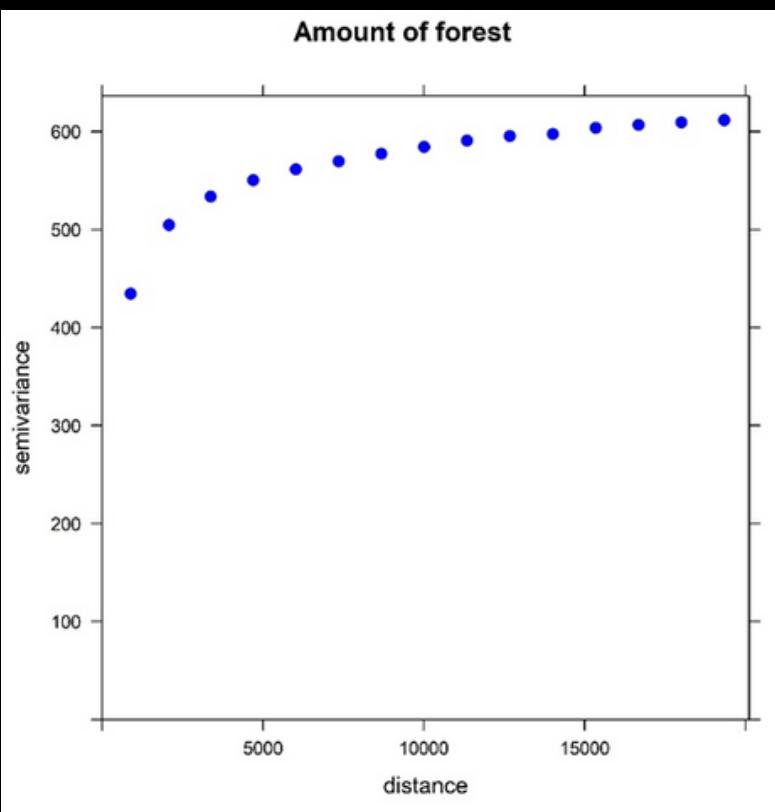




REFERENCES

- Figure introduction slide - <https://mol.org/patterns/high-res>
- Reside, A. E., Watson, I., VanDerWal, J., & Kutt, A. S. (2011). Incorporating low-resolution historic species location data decreases performance of distribution models. *Ecological Modelling*, 222(18), 3444-3448.
- Merow, C., Smith, M. J., Edwards Jr, T. C., Guisan, A., McMahon, S. M., Normand, S., ... & Elith, J. (2014). What do we gain from simplicity versus complexity in species distribution models?. *Ecography*, 37(12), 1267-1281
- Smith, A. B., Murphy, S. J., Henderson, D., & Erickson, K. D. (2021). Imprecisely georeferenced specimen data provide unique information on species' distributions and environmental tolerances: Don't let the perfect be the enemy of the good. *bioRxiv*.
- Gábor, L., Moudrý, V., Lecours, V., Malavasi, M., Barták, V., Fogl, M., ... & Václavík, T. (2020). The effect of positional error on fine scale species distribution models increases for specialist species. *Ecography*, 43(2), 256-269.
- Gábor, L., et al. (2022). Positional errors in species distribution modelling are not overcome by the coarser grains of analysis. *Methods in Ecology and Evolution*, Hopefully published soon.
- Naimi, B., Hamm, N. A., Groen, T. A., Skidmore, A. K., & Toxopeus, A. G. (2014). Where is positional uncertainty a problem for species distribution modelling? *Ecography*, 37(2), 191-203

ENVIRONMENTAL VARIABLES - CANTABRIAN BROWN BEAR



ENVIRONMENTAL VARIABLES - BAND-TAILED PIGEON

