

Two extensions of the vanilla GLLVM

Bert van der Veen

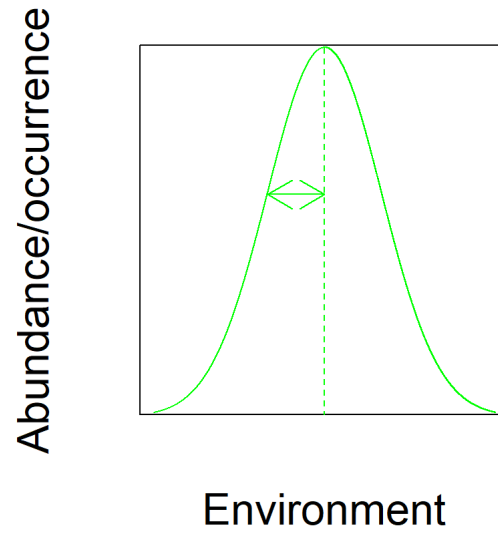
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In the introduction...

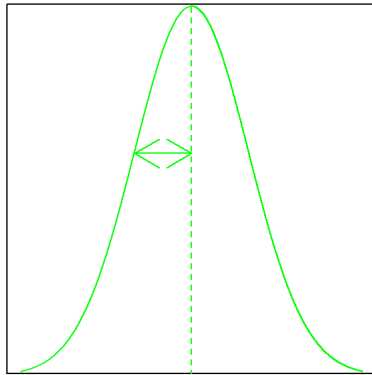
Occurrence pattern



Why analyse multivariate data?

Occurrence pattern

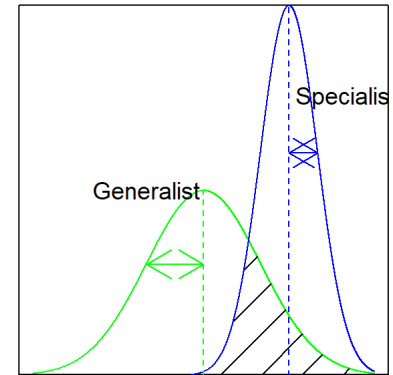
Abundance/occurrence



Environment

Co-occurrence pattern

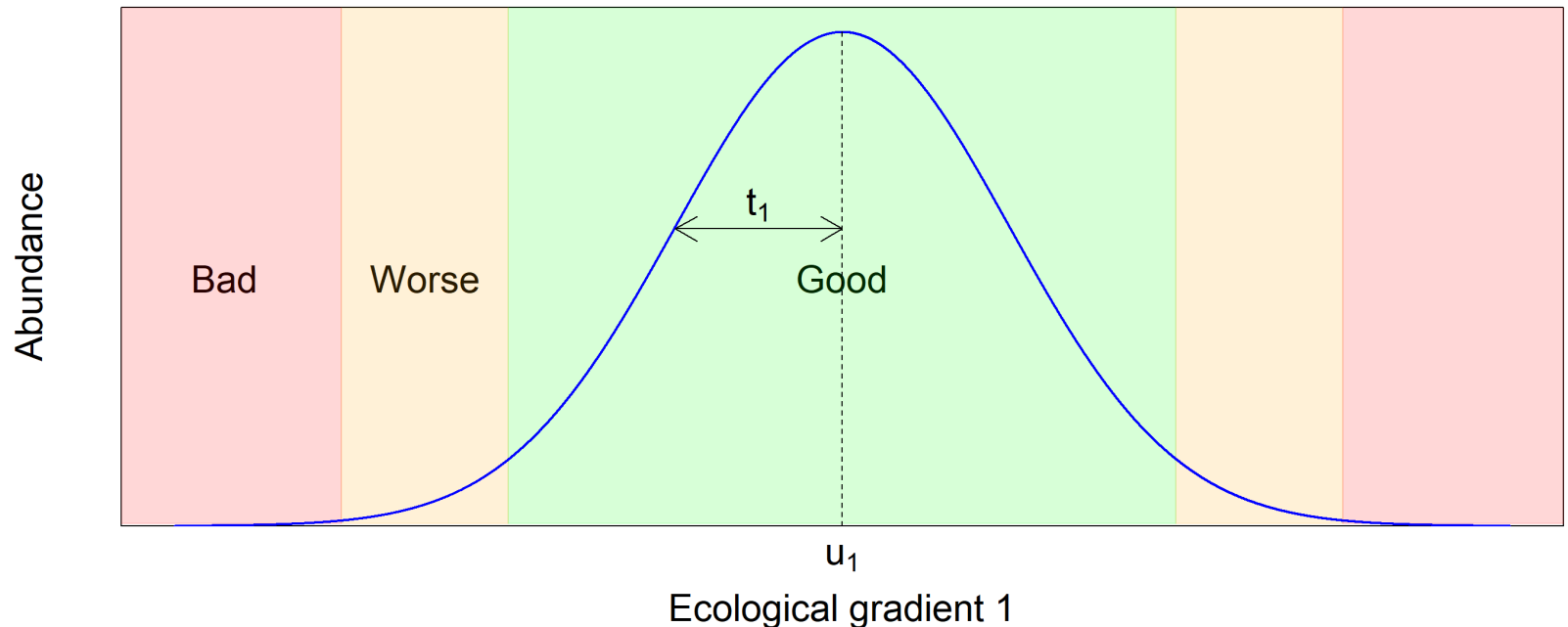
Abundance/occurrence



Environment

Motivation unimodal niches

- JSDMs and ordination often assume equal tolerances (or linear responses)
- Shelford's law of tolerance (1931)
- Specialist or generalist
- e.g., `glm(y~x+I(x^2))`



Species response models

- Much discussion on "correct" response model
- e.g.,
 - Austin 1976, 1980, 2002, Austin et al. 1990, 1994
 - Oksanen and Minchin 2002
 - Jansen and Oksanen 2013
- In ordination: unimodal responses ter Braak 1987
- van der Veen et al. 2021
- Most complex ordination method to date

Quadratic GLLVM

- Linear coefficients θ_j
- Quadratic coefficients in Positive-definite diagonal matrix D_j
 - Common tolerances $D_j = D$
 - Equal tolerances $D_{jqq} = D_{11}$

$$g(E(y_{ij}|z_i)) = \beta_{0j} + \epsilon_i^\top \theta_j - \epsilon_i^\top D_j \epsilon_i \quad (1)$$

- species tolerances $t_j = \frac{1}{\sqrt{2\text{diag}(D_j)}}$
- species optima $u_j = \frac{\theta_j}{2\text{diag}(D_j)}$
- i.e. unconstrained quadratic (residual) ordination or JSMD with quadratic latent variables

Species associations

- Similarly calculate residual correlations
- Emphasizes "positive" associations for same θ_j due to positive D_j
- To better capture species co-occurrence patterns

Vignette quadratic model

How to use the quadratic response model?

Constrained ordination

Indirect versus direct gradient analysis

- Unconstrained ordination: indirect
- Constrained ordination: direct
 - e.g., CCA, RDA
- Difference: how to derive meaning?
- I.e. what represents the latent variable?

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FORUM

Are ordination and constrained ordination alternative or complementary strategies in general ecological studies?

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Økland 2004

Model-based constrained ordination

- Also known as Reduced Rank Regression Anderson 1951
- Reduced number of parameters

Multivariate GLM or stacked SDM

$$g(E(y_{ij}|\mathbf{x}_i)) = \beta_{0j} + \mathbf{x}_i^\top \beta_j \quad (2)$$

- RRR: $\beta_j = \mathbf{B}\theta_j$
 - i.e. we have a model for the slope parameters
 - \mathbf{B} is a matrix of slopes for d latent variables
 - Ordination axes or LV: $\mathbf{B}^\top \mathbf{x}_i$
 - \mathbf{B} gives information on LV

Model-based constrained ordination

- Common issue: what if you only have few predictors?
- Random-effects to the rescue

$$g(E(y_{ij}|\mathbf{x}_i)) = \beta_{0j} + \mathbf{x}_i^\top \mathbf{B}\boldsymbol{\theta}_j + \boldsymbol{\epsilon}_i^\top \boldsymbol{\theta}_j \quad (3)$$

- Ordination axes or LV: $\mathbf{B}^\top \mathbf{x}_i + \boldsymbol{\epsilon}_i$
- So, RRR is a linear regression of LV without residual
- \mathbf{B} gives information on LV
- $\boldsymbol{\epsilon}_i$ is unexplained variation in the ecological gradient

Vignette quadratic model

Model-based constrained ordination

Wrap-up

You now know:

- 1) What ecological gradient analysis is
- 2a) That JSDMs and ordination are both used to study co-occurrence patterns of species
- 2b) And that these are the same in terms of GLLVM implementation
- 3) How to use the **gllvm** R-package Niku et al. 2019

Bayesian Ordination and Regression

- For GLLVMs (ordination) with spatial effects
- Bayesian, with MCMC (i.e. can be **slow**)

Methods in Ecology and Evolution



British Ecological Society

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APPLICATION

BORAL – Bayesian Ordination and Regression Analysis of Multivariate Abundance Data in R

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Hierarchical Modeling of Species

- For other cool GLLVM (JSDM) stuff
- Bayesian, with MCMC (i.e. can be **slow**)

Methods in Ecology and Evolution




APPLICATION



Open Access



Joint species distribution modelling with the R-package HMSC

Gleb Tikhonov, Øystein H. Opedal, Nerea Abrego, Aleksi Lehikoinen, Melinda M. J. de Jonge, Jari Oksanen, Otso Ovaskainen 

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Thanks!