

Package ‘ECDFniche’

May 7, 2026

Type Package

Title Empirical Cumulative Distribution Function Niche Modeling Tools

Version 0.5

Description Simulate ecological niche models using Mahalanobis distance, transform distances to suitability with 1 - empirical cumulative distribution function and 1 - chi-squared, and generate comparison figures.

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Encoding UTF-8

RoxygenNote 7.3.3

Depends R (>= 4.1.0)

Imports checkCLI, dplyr, ggpp, purrr, tidyr, ggplot2, lemon, MASS, stats

Suggests knitr, rmarkdown, roxyglobals, tictoc

VignetteBuilder knitr

Config/roxyglobals/filename generated-globals.R

Config/roxyglobals/unique TRUE

URL <https://luizesser.github.io/ECDFniche/>

NeedsCompilation no

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Repository CRAN

Date/Publication 2026-04-27 18:40:09 UTC

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create_distance_suitability_plot
Create distance–suitability plot

Description

Create distance–suitability plot

Usage

```
create_distance_suitability_plot(analysis_results)
```

Arguments

analysis_results
 List returned by ecdf_theoretical_niche().

Value

A ggplot object.

Examples

```
# Create ECDF-niche based on personalized options:
res <- ecdf_theoretical_niche(n = 3,
                             n_population = 20000,
                             sample_sizes = seq(50, 1000, 50),
                             seed = 123)

# Plot analysis results
create_distance_suitability_plot(res)
```

ecdf_compare_niche *Simulations and analyses of Mahalanobis distance-based habitat suitability*

Description

The objective is to compare the performance of habitat suitability calculated based on chi-squared cumulative distribution function and Empirical Cumulative Distribution Function (ECDF)

Usage

```
ecdf_compare_niche(  
  p_vals = 1:5,  
  n_vals = seq(20L, 500L, 20L),  
  n_reps = 30L,  
  seed = NULL  
)
```

Arguments

p_vals	Integer vector; number of predictor variables (dimensions).
n_vals	Integer vector; number of records (sample sizes).
n_reps	Integer; number of replicates per combination.
seed	Optional integer for reproducibility.

Details

Performs replicated simulations of multivariate normal data to evaluate the agreement between suitability derived from chi-squared distribution and empirical cumulative distribution function (ECDF).

Value

A list with:

- cor_plot: ggplot of correlation vs sample size.
- suit_plot: ggplot of suitability vs Mahalanobis distance.
- cond_plot: ggplot of correlation vs condition number.
- cor_df: raw correlation data.
- obs_df: observation-level data.
- cov_df: covariance diagnostics.

Author(s)

Matheus T. Baumgartner

Examples

```
# Create ECDF-niche based on personalized options:
n <- ecdf_compare_niche(p_vals = 1:3,
                        n_vals = seq(50L, 500L, 50L),
                        n_reps = 10L,
                        seed = 1991)
```

ecdf_nonnormal_niche *Compare ECDF and Chi-square suitability under non-normal data*

Description

Script to run a simulation study to compare Chi-square vs. ECDF approaches to quantify habitat suitability based on bivariate non-normal data. Bivariate data was simulated based on environmental variables (temperature and precipitation) using Gaussian copulas. Temperature followed a normal distribution while precipitation followed a Weibull distribution. The choices of the distributions were based on Haddad (2021) - Theoretical and Applied Climatology (for temperature) and on the estimation of rainfall in millimeters by Wilks (1989) - Journal of Applied Meteorology. Because the relationship between temperature and precipitation is complex across space (Rodrigo, 2022 - Theoretical and Applied Climatology), we defined five correlation values between the two variables.

temp_parameters and prec_parameters must comply to stats::qnorm or stats::qweibull, depending on the function chosen on temp_function and prec_function. For "qnorm", user can specify mean and sd, while for "qweibull"

Usage

```
ecdf_nonnormal_niche(
  rho_vals = c(-0.7, -0.3, 0, 0.3, 0.7),
  n_vals = c(20L, 50L, 100L, 200L, 500L),
  n_reps = 10L,
  N_ref = 1e+05,
  temp_function = "qnorm",
  temp_parameters = list(mean = 20, sd = 5),
  prec_function = "qweibull",
  prec_parameters = list(shape = 2, scale = 10),
  seed = NULL
)
```

Arguments

rho_vals	Numeric vector; correlations between variables.
n_vals	Integer vector; sample sizes.
n_reps	Integer; number of replicates.
N_ref	Integer; size of reference population for "true" parameters.

temp_function	Character; function used to model temperature values. One of: "qnorm" or "qweibull".
temp_parameters	List; list organizing parameters to pass to temp_function.
prec_function	Character; function used to model precipitation values. One of: "qnorm" or "qweibull".
prec_parameters	List; list organizing parameters to pass to temp_function.
seed	Optional integer for reproducibility.

Details

Simulates bivariate environmental data using Gaussian copulas with non-normal marginals (Normal for temperature and Weibull for precipitation), and evaluates agreement between chi-squared and ECDF suitability.

Value

A list with:

- suit_plot: ggplot of suitability vs Mahalanobis distance
- cor_df: correlation results
- obs_df: observation-level data

Author(s)

Matheus T. Baumgartner

Examples

```
# Create ECDF-niche based on personalized options:
n <- ecdf_nonnormal_niche(rho_vals = c(-0.7, -0.3, 0, 0.3, 0.7),
  n_vals = c(20L, 50L, 100L, 200L, 500L),
  n_reps = 10L,
  N_ref = 1e5,
  seed = 1991)
```

ecdf_theoretical_niche

Niche analysis using ECDF and chi-squared

Description

Simulate niche suitability from Mahalanobis distance using both chi-squared and empirical CDF transformations, for a given number of predictor variables.

Usage

```
ecdf_theoretical_niche(  
  n,  
  n_population = 10000L,  
  sample_sizes = seq(20L, 500L, 20L),  
  seed = NULL  
)
```

Arguments

n	Integer; number of predictor variables (dimensions).
n_population	Integer; size of simulated environmental population.
sample_sizes	Integer vector of sample sizes to evaluate.
seed	Optional integer seed for reproducibility.

Value

A list with:

- corplot: ggplot object with correlation vs sample size.
- sample_data: matrix of simulated sample points.
- sample_niche: numeric vector of “true” niche suitability.
- chisq_suits: numeric vector, 1 - pchisq(Mahalanobis).
- ecdf_suits: numeric vector, 1 - ECDF(Mahalanobis).
- mahal_dists: numeric vector of Mahalanobis distances.

Author(s)

Luíz Fernando Esser

Examples

```
# Create ECDF-niche based on personalized options:  
n <- ecdf_theoretical_niche(n = 3,  
  n_population = 20000,  
  sample_sizes = seq(50, 1000, 50),  
  seed = 123)
```

`mahal.dist`*Mahalanobis Distance Classifier for Ecological Niche Modeling*

Description

A custom caret model specification implementing a Mahalanobis distance-based classifier for ecological niche modeling (ENM) and species distribution modeling (SDM). This implementation supports both parametric (chi-squared) and nonparametric (empirical cumulative distribution function; ECDF) transformations of Mahalanobis distances into suitability scores.

Usage

`mahal.dist`

Format

An object of class `list` of length 12.

Details

The model is trained using presence-only data to estimate the centroid and covariance structure of environmental conditions associated with species occurrences. Suitability is then derived as the inverse tail probability of the Mahalanobis distance between new observations and the estimated niche centroid.

Two approaches are available to transform Mahalanobis distances into probabilities:

- `"chisq"`: assumes distances follow a chi-squared distribution with degrees of freedom equal to the number of predictors.
- `"ecdf"`: uses the empirical cumulative distribution function of training distances, providing a nonparametric estimate of suitability.

The ECDF-based approach is particularly useful when the assumption of multivariate normality is violated, which is common in ecological data.

This model can be used within the `caret::train()` framework, enabling resampling, tuning, and ensemble modeling workflows for ecological niche modeling.

Model Parameters

abs Logical. If TRUE, predictions are binarized using a fixed threshold (default: 0.05). If FALSE, the class with the highest predicted probability is returned.

method Character. Method used to convert Mahalanobis distances into suitability values. Options are `"chisq"` or `"ecdf"`.

Details

The Mahalanobis distance defines an ellipsoidal niche in environmental space. Under the chi-squared formulation, suitability decreases as the distance from the niche centroid increases. The ECDF formulation relaxes distributional assumptions by estimating suitability directly from the empirical distribution of distances observed in presence data.

Predictions return class probabilities for "presence" and "pseudoabsence", allowing flexible thresholding and ensemble integration.

Usage in caret

This object can be supplied to `caret::train()` as a custom model:

```
library(caret)

model <- train(
  x = predictors,
  y = response,
  method = mahal.dist,
  trControl = trainControl(classProbs = TRUE)
)
```

You can also run only ECDF by adjusting the tuning grid:

```
library(caret)

grid <- expand.grid(
  abs = c(TRUE, FALSE),
  method = "ecdf"
)

model <- train(
  x = predictors,
  y = response,
  method = mahal.dist,
  tuneGrid = grid,
  trControl = trainControl(classProbs = TRUE)
)
```

See Also

[mahalanobis](#), [ecdf](#), [train](#)

`run_ecdf_mahal_analysis`*Run full ECDF–Mahalanobis analysis*

Description

Convenience function that reproduces the three figures from the original manuscript for 1–5 dimensions.

Usage

```
run_ecdf_mahal_analysis(dims = 1:5, seed = 3L)
```

Arguments

<code>dims</code>	Integer vector of dimensions (default 1:5).
<code>seed</code>	Optional seed for reproducibility.

Value

A list containing:

- `analyses`: list of `ecdf_theoretical_niche()` outputs.
- `figure1`, `figure2`, `figure3`: grobs with arranged plots.

Examples

```
# Recreate original manuscript output:  
set.seed(3)  
full_res <- run_ecdf_mahal_analysis(dims = 1:5)
```

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