Package: climniche (via r-universe)

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Type Package

Title Niche Climate Exposure

Version 0.2.0

Description Assesses niche climate exposure by interpreting projected climate change relative to the climate conditions a species currently occupies. Using occurrence records, range data, continuous species distribution model suitability maps, current environmental rasters and future projections, the package separates Climatic Displacement, Niche Distance Shift, Climatic Reconfiguration and Niche Boundary Exceedance.

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URL https://github.com/Bohao0813/climniche, https://bohao0813.github.io/climniche/

BugReports https://github.com/Bohao0813/climniche/issues

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Imports grid, methods

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Contents

`boundary_exceedance` *Niche Boundary Exceedance*

Description

Niche Boundary Exceedance

Usage

```
boundary_exceedance(
  psi_future,
  boundary_value,
  scale = c("radial", "potential")
)
```

Arguments

psi_future	Future niche potential.
boundary_value	Empirical boundary of the current realised niche in potential units.
scale	"radial" returns exceedance beyond the niche boundary distance; "potential" returns exceedance beyond squared niche potential.

Value

Numeric vector.

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climniche_diagram_data

Build data for a niche climate exposure diagram

Description

Build data for a niche climate exposure diagram

Usage

```
climniche_diagram_data(
  x,
  scope = c("current", "all"),
  max_arrows = 350L,
  seed = 1L
)
```

Arguments

x	A fitted climniche object.
scope	"current" for current reference cells; "all" for all evaluated cells.
max_arrows	Maximum number of current to future arrows to keep.
seed	Random seed used when subsampling arrows.

Value

A list of data frames used by plot_climniche_diagram().

climniche_report *Build a climniche report*

Description

Build a climniche report

Usage

```
climniche_report(
  x,
  species = NULL,
  scope = c("current", "all"),
  top_variables = 5
)
```

Arguments

x	A fitted climniche_fit object.
species	Optional species name used in printed reports.
scope	"current" for current reference cells or "all" for all evaluated cells. Current-scope summaries use reference weights.
top_variables	Number of variable contributions to show.

Value

An object of class climniche_report.

climniche_showcase_data *Build data for the climniche summary figure*

Description

Build data for the climniche summary figure

Usage

```
climniche_showcase_data(
  x,
  scope = c("current", "all"),
  max_points = 6000L,
  seed = 1L,
  plane_bins = 45L,
  boundary_probs = seq(0.5, 0.99, 0.01),
  top_variables = 6L
)
```

Arguments

x	A fitted climniche object.
scope	"current" for current reference cells; "all" for all evaluated cells.
max_points	Maximum number of cells to keep for the exposure plane.
seed	Random seed used when subsampling cells.
plane_bins	Number of fixed bins used to summarize the exposure plane.
boundary_probs	Boundary quantiles used for the sensitivity curve.
top_variables	Number of variables to show.

Value

A list of data frames used by `plot_climniche_showcase()`.

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climniche_summary *Summarise climniche results*

Description

Summarise climniche results

Usage

```
climniche_summary(x, scope = c("current", "all"))
```

Arguments

x	A fitted `climniche_fit` object.
scope	"current" for current reference cells or "all" for all evaluated cells. Current-scope summaries use reference weights.

Value

A one-row data frame with metric summaries and the effective classification settings.

climniche_table *Extract a tidy climniche table*

Description

Extract a tidy climniche table

Usage

```
climniche_table(x, scope = c("current", "all"))
```

Arguments

x	A fitted climniche_fit object.
scope	"current" for current reference cells or "all" for all evaluated cells.

Value

A data frame with one row per evaluated cell, including occupied_weight, the four primary metrics and the old metric aliases.

fit_climniche *Fit niche climate exposure*

Description

Fit niche climate exposure

Usage

```
fit_climniche(
  current,
  future,
  occupied = NULL,
  occupied_threshold = NULL,
  cnfa = NULL,
  center = NULL,
  sensitivity = NULL,
  A = NULL,
  metric = c("diag", "factor"),
  boundary = 0.95,
  scale = TRUE,
  global_mean = NULL,
  global_sd = NULL,
  tolerance = NULL,
```

```
  tolerance_quantile = 0.1,
  stable_climate_change = NULL,
  stable_quantile = 0.25,
  stable_reconfiguration = NULL,
  stable_reconfiguration_quantile = 0.25,
  boundary_exceedance_tolerance = 0,
  conflict_ratio = 0.25
)
```

Arguments

current	Numeric matrix or data frame of current environmental values.
future	Numeric matrix or data frame of future environmental values.
occupied	NULL, logical vector, row indices, or a numeric vector with one value per row identifying current occurrence, range, or continuous SDM suitability weights.
occupied_threshold	Threshold used when occupied contains binary or continuous values. Values at or below the threshold receive zero reference weight; values above it keep their original value.
cnfa	Optional CENFA model object.
center	Optional realised niche centre in standardised climate space.
sensitivity	Optional environmental sensitivity weights.
A	Optional niche metric matrix.
metric	Metric construction when A is not supplied.
boundary	User-set quantile defining the empirical realised niche boundary. The default is 0.95.
scale	Logical. If TRUE, standardise current and future values.
global_mean	Optional means used for standardisation.
global_sd	Optional standard deviations used for standardisation.
tolerance	Optional user-set Niche Distance Shift tolerance. If NULL, the value is calculated from tolerance_quantile.
tolerance_quantile	Quantile of absolute Niche Distance Shift used when tolerance = NULL.
stable_climate_change	Optional user-set threshold for limited Climatic Displacement. If NULL, the value is calculated from stable_quantile.
stable_quantile	Quantile of Climatic Displacement used when stable_climate_change = NULL.
stable_reconfiguration	Optional user-set threshold for low Climatic Reconfiguration. If NULL, the value is calculated from stable_reconfiguration_quantile.
stable_reconfiguration_quantile	Quantile of Climatic Reconfiguration used when stable_reconfiguration = NULL.

`boundary_exceedance_tolerance`
: User-set tolerance for deciding whether future climate exceeds the empirical niche boundary.

`conflict_ratio`
: Minimum minority sign contribution share used to mark mixed variable responses. Set to NULL to disable this flag.

Details

The fitted object stores four primary metrics as snake_case fields: Climatic Displacement (`climate_change_amount`), Niche Distance Shift (`niche_distance_change`), Climatic Reconfiguration (`climate_reconfiguration`) and Niche Boundary Exceedance (`niche_boundary_exceedance`).

Let current and future climatic conditions at cell i be c_i and f_i. Let μ be the centre of the current realised climatic niche, and let $d_A(x, y)$ be the sensitivity weighted distance under weighting matrix A. The four metrics are

$$D_i = d_A(f_i, c_i)$$

$$R_i = d_A(f_i, \mu) - d_A(c_i, \mu)$$

$$C_i = \sqrt{\max(0, D_i^2 - R_i^2)}$$

$$E_i = \max(0, d_A(f_i, \mu) - B_q)$$

where B_q is the q-th weighted quantile of current reference cell distances from the realised niche centre. Positive Niche Boundary Exceedance is therefore an excess distance beyond this empirical radial boundary.

All classification-related thresholds are user-settable. If a direct threshold argument is `NULL`, `climniche` calculates the effective threshold from the corresponding quantile argument. The fitted object stores the effective values actually used in `classification_settings`.

Value

An object of class `climniche_fit`.

User-settable thresholds

- `boundary`: quantile used to define the empirical realised niche boundary.
- `tolerance`: direct Niche Distance Shift tolerance; otherwise `tolerance_quantile`.
- `stable_climate_change`: direct Climatic Displacement threshold for the limited-change class; otherwise `stable_quantile`.
- `stable_reconfiguration`: direct Climatic Reconfiguration threshold for the limited-change class; otherwise `stable_reconfiguration_quantile`.
- `boundary_exceedance_tolerance`: direct tolerance for Niche Boundary Exceedance.
- `conflict_ratio`: minority-sign contribution share used by the mixed variable-response diagnostic.

`fit_climniche_raster` *Fit climniche to raster data*

Description

Fit climniche to raster data

Usage

```
fit_climniche_raster(
  current,
  future,
  occupied = NULL,
  occupied_threshold = NULL,
  domain = NULL,
  domain_threshold = 0,
  ...
)
```

Arguments

`current`	Raster* object of current environmental layers.
`future`	Raster* object of future environmental layers.
`occupied`	Optional RasterLayer with binary or continuous occurrence, range, or SDM suitability values.
`occupied_threshold`	Values at or below this threshold receive zero reference weight. Values above it keep their original value.
`domain`	Optional RasterLayer limiting cells where exposure is analysed.
`domain_threshold`	Values greater than this threshold define the domain.
`...`	Additional arguments passed to `fit_climniche()`, including `boundary`, `tolerance`, `tolerance_quantile`, `stable_climate_change`, `stable_quantile`, `stable_reconfiguration`, `stable_reconfiguration_quantile`, `boundary_exceedance_tolerance` and `conflict_ratio`.

Value

An object of class `climniche_fit` with raster outputs.

`fit_climniche_terra` *Fit climniche to terra raster data*

Description

Fit climniche to terra raster data

Usage

```
fit_climniche_terra(
  current,
  future,
  occupied = NULL,
  occupied_threshold = NULL,
  domain = NULL,
  domain_threshold = 0,
  ...
)
```

Arguments

`current`	terra SpatRaster of current environmental layers.
`future`	terra SpatRaster of future environmental layers.
`occupied`	Optional one layer SpatRaster with binary or continuous occurrence, range, or SDM suitability values.
`occupied_threshold`	Values at or below this threshold receive zero reference weight. Values above it keep their original value.
`domain`	Optional one layer SpatRaster limiting cells where exposure is analysed.
`domain_threshold`	Values greater than this threshold define the domain.
`...`	Additional arguments passed to `fit_climniche()`, including `boundary`, `tolerance`, `tolerance_quantile`, `stable_climate_change`, `stable_quantile`, `stable_reconfiguration`, `stable_reconfiguration_quantile`, `boundary_exceedance_tolerance` and `conflict_ratio`.

Value

An object of class `climniche_fit` with raster outputs.

niche_metric *Build a sensitivity weighted niche metric*

Description

Build a sensitivity weighted niche metric

Usage

```
niche_metric(sensitivity = NULL, cnfa = NULL, type = c("diag", "factor"))
```

Arguments

sensitivity	Numeric vector of climate variable sensitivity weights.
cnfa	Optional CENFA cnfa object or list with sf, co, and eig.
type	Metric type. "diag" uses variable-level sensitivity weights. "factor" uses a factor metric when CNFA factor coordinates are available.

Value

A positive semi-definite matrix.

niche_percentile *Niche percentile shift*

Description

Niche percentile shift

Usage

```
niche_percentile(psi_current, psi_future, occupied)
```

Arguments

psi_current	Current niche potential for all cells.
psi_future	Future niche potential for all cells.
occupied	Current reference weights or indices used to define the reference CDF.

Value

Data frame with current, future, and delta percentiles.

niche_potential *Niche potential*

Description

Niche potential

Usage

```
niche_potential(x, center, A)
```

Arguments

x	Standardised climate matrix.
center	Realised niche centre.
A	Niche metric matrix.

Value

Numeric vector of quadratic niche displacement values.

niche_radius *Niche radius*

Description

Niche radius

Usage

```
niche_radius(psi)
```

Arguments

psi	Numeric niche-potential values.

Value

Numeric vector in sensitivity weighted climate distance units.

plot_climniche_class_summary *Plot climniche class proportions*

Description

Plot climniche class proportions

Usage

```
plot_climniche_class_summary(x, scope = c("current", "all"), title = NULL)
```

Arguments

x	A fitted climniche object.
scope	"current" for current reference cells or "all" for all evaluated cells.
title	Optional plot title.

Value

A ggplot object.

plot_climniche_classes *Plot climniche classes*

Description

Plot climniche classes

Usage

```
plot_climniche_classes(
  x,
  occupied = NULL,
  occupied_only = FALSE,
  occupied_threshold = NULL,
  title = NULL
)
```

Arguments

x	A fitted climniche object with raster outputs.
occupied	Optional current reference RasterLayer to overlay.
occupied_only	If TRUE, mask the plotted classes to current occurrence cells.
occupied_threshold	Threshold used when occupied contains binary or continuous values. Values above the threshold keep their original value when used as an overlay or mask.
title	Optional plot title. Use FALSE to suppress it.

Value

A ggplot object.

---

plot_climniche_diagram

Plot a niche climate exposure diagram

Description

Plot a niche climate exposure diagram

Usage

```
plot_climniche_diagram(
  x,
  scope = c("current", "all"),
  type = c("summary", "sample"),
  summary_layout = c("metrics", "ordination"),
  max_arrows = 350L,
  seed = 1L,
  show_reference = FALSE,
  show_hulls = TRUE,
  boundary_shape = c("hull", "circle", "none"),
  show_boundary_label = TRUE,
  show_points = NULL,
  show_startpoints = FALSE,
  show_endpoints = FALSE,
  show_center = TRUE,
  show_variables = FALSE,
  variable_labels = NULL,
  title = NULL
)
```

Arguments

x	A fitted climniche object or data returned by climniche_diagram_data().
scope	"current" for current reference cells; "all" for all evaluated cells.
type	"summary" draws mean current-to-future displacements for exposure classes; "sample" draws sampled cell displacements and future points.
summary_layout	Layout used when type = "summary". "metrics" draws the climate-space projection and two metric planes; "ordination" draws class mean arrows on the climate-space projection.
max_arrows	Maximum number of current to future arrows to draw when type = "sample".
seed	Random seed used when subsampling arrows.
show_reference	Logical; draw the full analysed climate-space domain.
show_hulls	Logical; draw current and future climate-space envelopes.
boundary_shape	Boundary display. "hull" draws the current reference climate envelope, "circle" draws a constant niche-distance boundary, and "none" suppresses the boundary.
show_boundary_label	Logical; add envelope explanations below the exposure-class legend.
show_points	Logical; draw future points when type = "sample".
show_startpoints	Logical; draw class mean current positions when type = "summary".
show_endpoints	Logical; draw class mean future positions when type = "summary".
show_center	Logical; mark the realised niche centre.
show_variables	Logical; draw environmental variable directions.
variable_labels	Optional named vector replacing variable labels.
title	Optional plot title.

Value

A ggplot object.

---

plot_climniche_distribution

Plot a climniche metric distribution

Description

Plot a climniche metric distribution

Usage

```
plot_climniche_distribution(
  x,
  metric = c("niche_distance_change", "climate_change_amount",
   "niche_boundary_exceedance", "climate_reconfiguration", "outside_niche_exceedance",
    "composition_change"),
  scope = c("current", "all"),
  title = NULL
)
```

Arguments

x	A fitted climniche object.
metric	Metric to plot.
scope	"current" for current reference cells or "all" for all evaluated cells.
title	Optional plot title.

Value

A ggplot object.

---

plot_climniche_exposure

Plot the climniche exposure plane

Description

Plot the climniche exposure plane

Usage

```
plot_climniche_exposure(
  x,
  scope = c("current", "all"),
  max_points = 6000,
  seed = 1,
  title = NULL
)
```

Arguments

x	A fitted climniche object.
scope	"current" for current reference cells or "all" for all evaluated cells.
max_points	Maximum number of points to draw.
seed	Random seed used when subsampling.
title	Optional plot title.

Value

A ggplot object.

`plot_climniche_map` *Plot a climniche map*

Description

Plot a climniche map

Usage

```
plot_climniche_map(
  x,
  metric = c("niche_distance_change", "niche_boundary_exceedance",
    "climate_change_amount", "climate_reconfiguration", "change_alignment",
    "outside_niche_exceedance", "composition_change"),
  occupied = NULL,
  occupied_only = FALSE,
  occupied_threshold = NULL,
  title = NULL,
  midpoint = 0
)
```

Arguments

`x`	A fitted climniche object with raster outputs, or a RasterLayer.
`metric`	Metric to plot.
`occupied`	Optional current reference RasterLayer to overlay.
`occupied_only`	If TRUE, mask the plotted raster to current occurrence cells.
`occupied_threshold`	Threshold used when `occupied` contains binary or continuous values. Values above the threshold keep their original value when used as an overlay or mask.
`title`	Optional plot title. Use `FALSE` to suppress it.
`midpoint`	Midpoint for the Niche Distance Shift colour scale.

Value

A ggplot object.

plot_climniche_report *Plot a climniche report figure*

Description

Plot a climniche report figure

Usage

```
plot_climniche_report(x, scope = c("current", "all"))
```

Arguments

x	A fitted climniche object.
scope	"current" for current reference cells or "all" for all evaluated cells.

Value

A patchwork object when patchwork is installed, otherwise a named list of ggplot objects.

plot_climniche_showcase *Plot the climniche summary figure*

Description

Plot the climniche summary figure

Usage

```
plot_climniche_showcase(
  x,
  scope = c("current", "all"),
  max_points = 6000L,
  seed = 1L,
  plane_bins = 45L,
  boundary_probs = seq(0.5, 0.99, 0.01),
  top_variables = 6L,
  variable_labels = NULL,
  title = NULL
)
```

Arguments

x	A fitted climniche object or data returned by climniche_showcase_data().
scope	"current" for current reference cells; "all" for all evaluated cells.
max_points	Maximum number of cells to draw in the exposure plane.
seed	Random seed used when subsampling cells.
plane_bins	Number of fixed bins used to summarize the exposure plane.
boundary_probs	Boundary quantiles used for the sensitivity curve.
top_variables	Number of variables to show.
variable_labels	Optional named vector replacing variable labels.
title	Optional overall title when patchwork is installed.

Value

A patchwork object when patchwork is installed, otherwise a named list of ggplot objects.

---

plot_climniche_variable_contribution

Plot mean variable contribution

Description

Plot mean variable contribution

Usage

```
plot_climniche_variable_contribution(
  x,
  occupied_only = TRUE,
  variable_labels = NULL,
  title = NULL
)
```

Arguments

x	A climniche_fit object.
occupied_only	If TRUE, summarize occupied cells only.
variable_labels	Optional named vector replacing variable labels.
title	Optional plot title. Use FALSE to suppress it.

Value

A ggplot object.

plot_variable_contribution *Plot mean variable contribution*

Description

Plot mean variable contribution

Usage

```
plot_variable_contribution(
  x,
  occupied_only = TRUE,
  variable_labels = NULL,
  title = NULL
)
```

Arguments

x	A climniche_fit object.
occupied_only	If TRUE, summarize occupied cells only.
variable_labels	Optional named vector replacing variable labels.
title	Optional plot title. Use FALSE to suppress it.

Value

A ggplot object.

simulate_climniche *Simulate a minimal climate niche change experiment*

Description

Simulate a minimal climate niche change experiment

Usage

```
simulate_climniche(
  n = 2000,
  p = 2,
  seed = 1,
  rho = 0,
  prevalence = 0.3,
  shift = 0.4
)
```

Arguments

n	Number of climate cells.
p	Number of climate variables.
seed	Random seed.
rho	Pairwise correlation among simulated climate variables.
prevalence	Proportion of background cells treated as true current occurrence locations under the virtual niche.
shift	Climatic Displacement imposed in the closer to niche and farther from niche scenarios.

Value

A list with current, future_toward, future_away, occupied, center, sensitivity and A.

---

variable_contribution *Variable contribution to change in niche potential*

Description

Variable contribution to change in niche potential

Usage

```
variable_contribution(current, future, center, A)
```

Arguments

current	Current standardized climate matrix.
future	Future standardized climate matrix.
center	Realised niche centre.
A	Niche metric matrix.

Value

Matrix whose rows sum to the change in niche potential.

`write_climniche_report` *Write a climniche report to Markdown*

Description

Write a climniche report to Markdown

Usage

```
write_climniche_report(report, file)
```

Arguments

`report`	An object returned by `climniche_report()`.
`file`	Output Markdown file.

Value

Invisibly returns `file`.

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