

Package ‘virtualNicheR’

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Type Package

Title Generating Virtual Fundamental and Realised Niches

Version 1.0

Maintainer Thomas R. Etherington <etheringtont@landcareresearch.co.nz>

Description The ability to generate virtual niches enables virtual ecology experiments that have been advocated for evaluating species-environment relationship models. Using multivariate normal distributions and matrix algebra this package provides a unique computational framework to generate integrated fundamental and realised niches, which is important given differences in possible complexity of realised niche shapes that result from biotic interactions Etherington and Omondiagbe (2019) <doi:10.21105/joss.01661>.

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Suggests testthat, knitr, rmarkdown

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Author Thomas R. Etherington [aut, cre],
O. Pascal Omondiagbe [aut],
Landcare Research New Zealand Ltd [cph]

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R topics documented:

fund.niche	2
niche.grid.coords	3
rainfallMap	4
real.niche	5
temperatureMap	6

fund.niche

Fundamental Niche

Description

Calculates the n-dimensional fundamental niche at m coordinates in niche space.

Usage

```
fund.niche(niche.coords, species)
```

Arguments

`niche.coords` A m-by-n matrix of niche coordinates.

`species` Ordered list of: maximum finite rate of increase, a means vector, and variance-covariance matrix that together define the fundamental niche of the species.

Details

Fundamental niche values are calculated on the basis of a multi-variate normal distribution, and hence are unimodal and convex in shape. The `niche.coords` can either be coordinates of specific interest, such as for mapping niche suitability for a study area, or for visualisation in niche space a grid of systematic coordinates as can be generated using `niche.grid.coords`. The species ordered list should contain:

- maximum finite rate of increase, the species' maximum finite rate of increase at the fundamental niche optimum,
- a n-by-1 column vector of means that gives the optimum location of the niche in each dimension, and
- a n-by-n variance-covariance matrix, that gives the size and orientation of the niche in each dimension.

Value

Returns a vector of length m containing the fundamental niche value for each of the input niche space coordinates.

References

Etherington TR, Omondiagbe OP (2019) virtualNicheR: generating virtual fundamental and realised niches for use in virtual ecology experiments. *Journal of Open Source Software* 4:1661 <https://doi.org/10.21105/joss.01661>

See Also

Used internally by `real.niche`

Examples

```

# Create coordinates across niche space
niche.XY = niche.grid.coords(mins=c(15,0), maxs=c(35,200), nCoords=121)
# Define a species as a function of the maximum finite rate of increase,
# a means vector, and covariance matrix
lambdaMax = 2.5
meansVector = matrix(c(25, 100))
covarMatrix = matrix(data=c(9, 60,
                           60, 625), nrow=2, ncol=2, byrow = TRUE)
species = list(lambdaMax, meansVector, covarMatrix)
# Calculate the fundamental niche
fundNiche = fund.niche(niche.XY, species)
# Plot the fundamental niche
fundNicheMatrix = matrix(fundNiche, nrow=length(unique(niche.XY[,1])))
nContour = 10
filled.contour(unique(niche.XY[,1]), unique(niche.XY[,2]), fundNicheMatrix,
               levels = seq(0, lambdaMax, lambdaMax/nContour),
               col=colorRampPalette(c("gold", "firebrick"))(nContour),
               xlab=expression(paste("Temperature (", degree, "C)")),
               ylab="Rainfall (mm)",
               main = "Fundamental niche",
               key.title = title(main = expression(lambda)))

# Map the potential niche given maps of environmental variables
# Convert matrices of variables into columns
temp1D = matrix(temperatureMap, ncol=1)
rain1D = matrix(rainfallMap, ncol=1)
data.XY = cbind(temp1D, rain1D)
# Calculate the potential niche and form back in a 2D map
poteNiche = fund.niche(data.XY, species)
poteNiche2D = matrix(poteNiche, ncol=100)
filled.contour(z=poteNiche2D,
               levels = seq(0, lambdaMax, lambdaMax/nContour),
               col=colorRampPalette(c("gold", "firebrick"))(nContour),
               asp=1, plot.axes = {}, frame.plot=FALSE,
               main = "Map of the potential niche",
               key.title = title(main = expression(lambda)))

```

niche.grid.coords *Niche Grid Coordinates*

Description

Create an n-dimensional grid of coordinates across niche space.

Usage

```
niche.grid.coords(mins, maxs, nCoords)
```

Arguments

mins	Vector of length n listing the niche space minimum for each dimension.
maxs	Vector of length n listing the niche space maximum for each dimension.
nCoords	Number of coordinates across the niche space in all dimensions.

Details

This function creates a grid of coordinates systematically located throughout the specified niche space to enable visualisation of niche patterns. The extent of the grid is given by the mins and maxs, and the number of coordinates for each dimension is given by nCoords.

Value

A matrix with n columns.

References

Etherington TR, Omondiagbe OP (2019) virtualNicheR: generating virtual fundamental and realised niches for use in virtual ecology experiments. *Journal of Open Source Software* 4:1661
<https://doi.org/10.21105/joss.01661>

Examples

```
# Niche space grid coordinates usage
niche.XY = niche.grid.coords(mins=c(15,0), maxs=c(35,200), nCoords=5)
```

rainfallMap	<i>A randomly generated field representing a continuous rainfall gradient</i>
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Description

A randomly generated field representing a continuous rainfall gradient

Usage

```
rainfallMap
```

Format

A two-dimensional matrix with 100 rows and 100 columns

...

`real.niche`*Realised Niche*

Description

Calculates the n-dimensional realised niche for a community of s species at m coordinates in niche space.

Usage

```
real.niche(niche.coords, community, interactions)
```

Arguments

<code>niche.coords</code>	A m-by-n matrix of niche coordinates.
<code>community</code>	List of length s containing definitions of the fundamental niches of species in the community.
<code>interactions</code>	A s-by-s matrix that defines the species interspecific interactions.

Details

The first step in calculating the realised niches is to calculate a fundamental niche for each species in the community list. This is done using the `fund.niche` function, so see there for a full description of how to define a the species fundamental niches.

The interactions matrix defines the form of the ecological interaction between each of the species in the community. These interactions can be either positive (+) or negative (-) in effect, and as the interactions can be asymmetrical there are a range of possible interspecific species interactions: competition (-), predator-prey or parasite-host (+-), commensalism (+0), amensalism (-0), or mutualism (++). When building the interactions matrix row 1 column 2 is the effects of species 2 on species 1, and conversely row 2 column 1 is the effects of species 1 on species 2, etc.

Please note that this function assumes that the species are consistently ordered in the community list and interactions matrix, and that no species effects itself so the diagonal of the interactions matrix has values equal to zero.

Value

Returns a m-by-s matrix realised niche value for each species at each of the input niche space coordinates.

References

Etherington TR, Omondiagbe OP (2019) virtualNicheR: generating virtual fundamental and realised niches for use in virtual ecology experiments. *Journal of Open Source Software* 4:1661 <https://doi.org/10.21105/joss.01661>

See Also

Uses [fund.niche](#)

Examples

```
# Define the community
species1 = list(2.5, matrix(c(25, 100)), matrix(data=c(9, 60,
                                                    60, 625), nrow=2, ncol=2, byrow=TRUE))
species2 = list(5.0, matrix(c(28, 110)), matrix(data=c(4, -20,
                                                    -20, 500), nrow=2, ncol=2, byrow=TRUE))
species3 = list(3.0, matrix(c(25, 80)), matrix(data=c(4, 0,
                                                    0, 150), nrow=2, ncol=2, byrow=TRUE))
community = list(species1, species2, species3)

# Define the interactions
interactions = matrix(data=c(0.0, 0.2,-0.4,
                             -1.0, 0.0,-1.0,
                             -0.6, 0.3, 0.0), nrow=3, ncol=3, byrow = TRUE)

# Calculate the realised niche values
niche.XY = niche.grid.coords(mins=c(15,0), maxs=c(35,200), nCoords=121)
realNiche = real.niche(niche.XY, community, interactions)

# Plot the realised niche for species 1
realNiche1 = matrix(realNiche[,1], nrow=length(unique(niche.XY[,1])))
nContour = 10
filled.contour(unique(niche.XY[,1]), unique(niche.XY[,2]), realNiche1,
              levels = seq(0, 5, 5/nContour),
              col=colorRampPalette(c("gold", "firebrick"))(nContour),
              xlab=expression(paste("Temperature (", degree, "C)")),
              ylab="Rainfall (mm)",
              main ="Realised niche",
              key.title = title(main = expression(lambda)))
```

temperatureMap	<i>A randomly generated field representing a continuous temperature gradient</i>
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Description

A randomly generated field representing a continuous temperature gradient

Usage

```
temperatureMap
```

temperatureMap

7

Format

A two-dimensional matrix with 100 rows and 100 columns

...

Index

*Topic **datasets**

rainfallMap, [4](#)

temperatureMap, [6](#)

fund.niche, [2](#), [5](#), [6](#)

niche.grid.coords, [2](#), [3](#)

rainfallMap, [4](#)

real.niche, [2](#), [5](#)

temperatureMap, [6](#)