Package 'rLakeHabitat'

April 15, 2025

Type Package

Title Interpolate Bathymetry and Quantify Physical Aquatic Habitat

Version 1.0.0

Date 2025-04-09

URL https://gitlab.com/tristanblechinger/rlakehabitat

BugReports https://gitlab.com/tristanblechinger/rlakehabitat/-/issues

Depends R (>= 4.3.0)

Imports dplyr, terra, gstat, sf, ggplot2, gganimate, tidyterra, rLakeAnalyzer, isoband

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Description Offers bathymetric interpolation using Inverse Distance Weighted and Ordinary Kriging via the 'gstat' and 'terra' packages. Other functions focus on quantifying physical aquatic habitats (e.g., littoral, epliminion, metalimnion, hypolimnion) from interpolated digital elevation models (DEMs). Functions were designed to calculate these metrics across water levels for use in reservoirs but can be applied to any DEM and will provide values for fixed conditions. Parameters like Secchi disk depth or estimated photic zone, thermocline depth, and water level fluctuation depth are included in most functions.

License GPL (>= 3)

VignetteBuilder knitr

Encoding UTF-8

RoxygenNote 7.3.2

Suggests testthat (>= 3.0.0), knitr, rmarkdown

Config/testthat/edition 3

NeedsCompilation no

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Repository CRAN

Date/Publication 2025-04-15 19:30:02 UTC

Contents

`animBathy` *Generate Animated Plot*

Description

Generate an animated plot of littoral area at different water level increments from a raster digital elevation model (DEM).

Usage

```
animBathy(
  DEM,
  units = "ft",
  littoral = TRUE,
  secchi = NULL,
  photic = NULL,
  stop = NULL,
  by = 1
)
```

Arguments

`DEM`	SpatRaster object of a given waterbody, rasters can be transformed to SpatRaster via the rast() function in 'terra'
`units`	character describing depth units of DEM. Can be meters ("m") or feet ("ft"). Default = "ft"
`littoral`	logical indicating if littoral zone should be plotted (T) or entire waterbody (F), default = TRUE
`secchi`	number giving the average Secchi depth of the waterbody, photic zone estimated as 2.6m * secchi

photic	number giving the average photic depth of the waterbody, overwrites Secchi
stop	optional numeric value specifying depth at which to stop animation, default = NULL (all depths)
by	numeric value specifying depth increments between plots. Higher values will result in lower resolution. Default = 1

Value

an animated ggplot object

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load raster
DEM <- terra::rast(system.file("extdata", "example_raster.tif", package = 'rLakeHabitat'))

#run function
animBathy(DEM, units = 'm', littoral = TRUE, secchi = 1, by = 5)
```

---

bathyMap *Plot Bathymetry Map*

Description

Generate a bathymetry map from a provided DEM raster with optional contours and depth labels.

Usage

```
bathyMap(
  DEM,
  contours = TRUE,
  start = NULL,
  end = NULL,
  by = 5,
  breaks = NULL,
  units = "ft",
  labels = TRUE,
  textSize = 1.5,
  plotTitle = NULL
)
```

Arguments

DEM	SpatRaster object of a given waterbody, rasters can be transformed to SpatRaster via the rast() function in 'terra'
contours	logical indicating whether contours should included (TRUE) or not (FALSE), default = TRUE
start	numeric value describing what value contours should start at, default = 0
end	numeric value describing what value contours should end at, default = max depth
by	numeric value describing contour intervals, default = 5
breaks	optional numeric vector describing specific contours to include if contours = T, default = NULL
units	character describing units of depth measurement, default = "ft"
labels	logical indicating whether labels should be included (TRUE) or not (FALSE), default = TRUE
textSize	number describing text size of contour labels if included, default = 1.5
plotTitle	optional character string adding title to output plot

Value

ggplot object

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load raster
DEM <- terra::rast(system.file("extdata", "example_raster.tif", package = 'rLakeHabitat'))
#run function
bathyMap(DEM, contours = TRUE, units = 'm', labels = TRUE)
```

---

calcHyps *Calculate Hypsography*

Description

Calculates area at each depth for a given waterbody.

Usage

```
calcHyps(DEM, DEMunits = "m", depthUnits = "ft", by = 1, output = "values")
```

Arguments

DEM	SpatRaster object of a given waterbody, rasters can be transformed to SpatRaster via the rast() function in 'terra'
DEMunits	character describing units of raster coordinate system. Can be meters, kilometers, or hectares ("m", "km", "ha"), default = "m"
depthUnits	character describing units of depth measurement. Can be either feet or meters ("ft", "m"), default = "ft"
by	numeric increment per unit by which volumes are calculated. Higher values will result in lower resolution. Default = 1
output	character describing desired output, can either be a data frame of values ("values") or a hypsography plot ("plot"). Default = "values"

Value

data frame of areas at each depth unit ("values") or a hypsography plot ("plot")

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load raster
DEM <- terra::rast(system.file("extdata", "example_raster.tif", package = 'rLakeHabitat'))
#run function
calcHyps(DEM, DEMunits = 'm', depthUnits = 'm', by = 1, output = 'values')
```

---

calcLittoral *Calculate Littoral Area*

Description

Calculates littoral surface area (2D) of a given waterbody across water levels based on an average photic depth value.

Usage

```
calcLittoral(
  DEM,
  photic = NULL,
  secchi = NULL,
  DEMunits = "m",
  depthUnits = "ft",
  by = 1,
  stop = NULL
)
```

Arguments

DEM	SpatRaster object of a given waterbody, rasters can be transformed to SpatRaster via the rast() function in 'terra'
photic	number giving the average photic depth, overwrites Secchi depth
secchi	number giving the average secchi depth, photic zone estimated as 2.6m * secchi.
DEMunits	character describing units of raster coordinate system. Can be meters, kilometers, or hectares ("m", "km", "ha"), default = "m"
depthUnits	character describing units of depth measurement (secchi and DEM). Can be either feet or meters ("ft", "m"), default = "ft"
by	numeric increment per unit depth by which areas are calculated. Higher values will result in lower resolution. Default = 1
stop	optional numeric value specifying depth at which to stop calculations, default = NULL

Value

data frame of areas in specified units for each depth, as well as the littoral percentage of total surface area

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load raster
DEM <- terra::rast(system.file("extdata", "example_raster.tif", package = 'rLakeHabitat'))
#run function
calcLittoral(DEM, secchi = 1, depthUnits = "m", DEMunits = "m")
```

---

calcSDI *Calculate Shoreline Development Index*

Description

Calculates Shoreline Development Index value across water levels for a given waterbody.

Usage

```
calcSDI(DEM, units = "m", by = 1, stop = NULL)
```

Arguments

DEM	SpatRaster object of a given waterbody, rasters can be transformed to SpatRaster via the rast() function in 'terra'
units	character describing units of raster coordinate system. Can be meters, kilometers, or hectares ("m", "km", "ha"), default = "m"
by	numeric increment per unit depth by which areas are calculated. Higher values will result in lower resolution. Default = 1
stop	optional numeric value specifying depth at which to stop calculations, default = NULL

Value

data frame of perimeter lengths and SDI values for given depths

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load raster
DEM <- terra::rast(system.file("extdata", "example_raster.tif", package = 'rLakeHabitat'))
#run function
calcSDI(DEM, units = 'm')
```

---

calcVolume *Calculate Pelagic Habitat Volumes*

Description

Calculates epilimnion, metalimnion, and hypolimnion volumes based on defined thermocline depths across water levels.

Usage

```
calcVolume(
  DEM,
  thermo_depth = NULL,
  thermo_high,
  thermo_low,
  DEMunits = "m",
  depthUnits = "ft",
  by = 1,
  stop = NULL
)
```

Arguments

DEM	SpatRaster object of a given waterbody, rasters can be transformed to SpatRaster via the rast() function in 'terra'
thermo_depth	number giving the estimated middle of thermocline, results in calculation of only epilimnion and hypolimnion volumes. Default = NULL, cannot use in conjunction with thermo_low and thermo_high
thermo_high	number giving the upper bound of thermocline depth, results in calculation of epilimnion, metalimnion, and hypolimnion values
thermo_low	number giving the lower bound of thermocline depth, results in calculation of epilimnion, metalimnion, and hypolimnion values
DEMunits	character describing units of raster coordinate system. Can be meters, kilometers, or hectares ("m", "km", "ha"), default = "m"
depthUnits	character describing units of depth measurement. Can be either feet or meters ("ft", "m"), default = "ft"
by	numeric increment per unit by which volumes are calculated. Higher values will result in lower resolution. Default = 1
stop	optional numeric value specifying depth at which to stop habitat volume calculations, default = NULL

Value

a data frame of volumes in cubic meters calculated for each habitat (epilimnion, metalimnion, hypolimnion)

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load raster
DEM <- terra::rast(system.file("extdata", "example_raster.tif", package = 'rLakeHabitat'))
#run function
calcVolume(DEM, thermo_depth = 3, DEMunits = 'm', depthUnits = 'm')
```

---

contourPoints *Contour Lines to Points*

Description

Get point coordinates and depth values along predetermined contours at a specified density.

Usage

```
contourPoints(object, depths = NULL, geometry = "geometry", density = 10)
```

Arguments

object	polygon or multipolygon shapefile (.shp) with depths included as an attribute column. Can be an sf or spatVector object.
depths	character string describing column name of depth attribute
geometry	character string describing column name of geometries. Default = "geometry"
density	numeric value describing distance between points in meters, default = 10m

Value

dataframe of coordinates and associated depths

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
# load test data
data <- sf::read_sf(system.file("extdata", "example_contour.shp", package = 'rLakeHabitat'))
#run function
contourPoints(data, depths = "Z", geometry = "geometry", density = 50)
```

---

crossValidate *Cross Validate Interpolated Bathymetry*

Description

Obtain residual mean square error (RMSE) from K-fold cross validation of bathymetry interpolation.

Usage

```
crossValidate(
  outline,
  df,
  x,
  y,
  z,
  zeros = FALSE,
  separation = NULL,
  k = 5,
  crsUnits = "dd",
  res = 5,
  method = "IDW",
  fact = NULL,
  nmax = 20,
```

```
  idp = 2,
  model = "Sph",
  psill = NULL,
  range = NULL,
  nugget = 0,
  kappa = NULL
)
```

Arguments

outline	shapefile outline of a waterbody
df	dataframe of coordinates and depths for a given waterbody
x	character giving name of longitude column
y	character giving name of latitude column
z	character giving name of depth column
zeros	logical describing if bounding zeros are needed (FALSE) or provided (TRUE), default = FALSE
separation	number describing distance between points, units from CRS
k	numeric value describing the number of folds to test, default = 5
crsUnits	character describing CRS units of input outline, either "dd" (decimal degrees) or "m" (meters), default = "dd"
res	number describing desired cell resolution in meters, default = 5
method	character describing method of interpolation, options include Inverse Distance Weighted ("IDW") or Ordinary Kriging ("OK"). Default = "IDW"
fact	numeric value describing the factor by which raster resolution should be increased, default = NULL. If 'crsUnits' and 'res' are defined, fact = NULL
nmax	numeric value describing number of neighbors used in interpolation, default = 20
idp	numeric value describing inverse distance power value for IDW interpolation
model	character describing type of model used in Ordinary Kriging, options include 'Sph', 'Exp', 'Gau', 'Sta', default = 'Sph'
psill	numeric value describing the partial sill value for OK interpolation, default = NULL
range	numeric describing distance beyond which there is no spatial correlation in Ordinary Kriging models, default = NULL
nugget	numeric describing variance at zero distance in Ordinary Kriging models, default = 0
kappa	numeric value describing model smoothness, default = NULL

Details

If both 'crsUnit' and 'res' = NULL, the output raster will be in the same CRS and units as the input 'outline' and the resolution will be increased by 'fact' (default = 10). If both 'crsUnit' and 'res' are defined, fact = NULL and the output raster will be projected to the most appropriate UTM zone at the specified resolution.

For the model argument there are four different methods included here that are supported by gstat::vgm ("Sph", "Exp", "Gau", "Mat"). "Sph" = The default gstat::vgm method. Spherical model characterized by a curve that rises steeply to defined range then flattens, indicates no spatial correlation between points beyond that range. "Exp" = Exponential model characterized by spatial correlation decaying with distance. "Gau" = Gaussian model similar to spatial model but with stronger decay at shorter distances. "Mat" = Matern model Three parameters (psill, range, kappa) are incorporated from a fitted variogram (default = NULL). If specified in function input, chosen values will overwrite variogram values.

Value

mean RMSE value across k number of folds

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load example outline
outline <- terra::vect(system.file("extdata", "example_outline.shp", package = 'rLakeHabitat'))
#load example xyz data
data <- read.csv(system.file("extdata", "example_depths.csv", package = 'rLakeHabitat'))
#run function
crossValidate(outline, data, "x", "y", "z", zeros = FALSE, separation = 10, k = 5, crsUnit = "dd",
res = 50, method = "IDW", nmax = 4, idp = 1.5)
```

---

estThermo *Estimate Average Thermocline Depth*

Description

Estimate average thermocline depth across multiple sites and dates.

Usage

```
estThermo(data, site, date, depth, temp, combine = "all")
```

Arguments

data	data frame of water column temperature profiles
site	character giving the name of the site column
date	character giving the name of the date column
depth	character giving the name of the depth column
temp	character giving the name of the temp column
combine	logical indicating whether or not to average across sites ("sites"), dates ("dates"), or sites and dates ("all"), default = "all"

Value

either numeric value of average thermocline depth, standard deviation, and n or data frame of thermocline depths, standard deviations, and n across sites or dates

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
# load test profile data
data <- read.csv(system.file("extdata", "example_profile_data.csv", package = 'rLakeHabitat'))
data$date <- base::as.Date(data$date)
#run function
estThermo(data = data, site = "site", date = "date",
depth = "depth", temp = "temp", combine = "all")
```

---

genStack *Create Raster Stack*

Description

Create a raster stack from a single raster, option to save as file.

Usage

```
genStack(
  DEM,
  by = 1,
  stop = NULL,
  save = TRUE,
  file_name = NULL,
  file_type = "COG"
)
```

Arguments

DEM	raster object
by	numeric increment per unit depth by which layers are split. Default = 1
stop	optional numeric value specifying depth at which to stop stacking rasters, default = NULL
save	logical, save raster stack (TRUE) or not (FALSE), default = TRUE
file_name	character string used to name saved raster stack
file_type	character string defining file type to save, default = "COG"

Value

a raster stack of specified depth increments for a given waterbody. Raster stack is either stored as an object (save = FALSE) or written to a file in the directory (save = TRUE).

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load raster
DEM <- terra::rast(system.file("extdata", "example_raster.tif", package = 'rLakeHabitat'))
#run function
genStack(DEM, by = 1, save = FALSE)
```

---

interpBathy *Interpolate bathymetry*

Description

Generate a bathymetric digital elevation model (DEM) for a given waterbody using either Inverse Distance Weighting or Ordinary Kriging interpolation. For high densities of point data, we recommend rarifying prior to interpolation to improve accuracy and reduce computation time (see rarify function).

Usage

```
interpBathy(
  outline,
  df,
  x,
  y,
  z,
  zeros = FALSE,
  separation = NULL,
  crsUnits = "dd",
```

```
  res = 10,
  method = "IDW",
  fact = NULL,
  nmax = 20,
  idp = 2,
  model = "Sph",
  psill = NULL,
  range = NULL,
  nugget = 0,
  kappa = NULL
)
```

Arguments

outline	shapefile outline of a waterbody
df	dataframe of coordinates and depths for a given waterbody
x	character giving name of longitude column
y	character giving name of latitude column
z	character giving name of depth column
zeros	logical describing if bounding zeros are needed (FALSE) or provided (TRUE), default = FALSE
separation	number describing distance between points, units from CRS
crsUnits	character describing CRS units of input outline, either "dd" (decimal degrees) or "m" (meters), default = "dd"
res	number describing desired cell resolution in meters, default = 10
method	character describing method of interpolation, options include Inverse Distance Weighted ("IDW") or Ordinary Kriging ("OK"). Default = "IDW"
fact	numeric value describing the factor by which raster resolution should be increased, default = NULL If 'crsUnits' and 'res' are defined, fact = NULL
nmax	numeric value describing number of neighbors used in interpolation, default = 20
idp	numeric value describing inverse distance power value for IDW interpolation
model	character describing type of model used in Ordinary Kriging, options include 'Sph', 'Exp', 'Gau', 'Sta', default = 'Sph'
psill	numeric value describing the partial sill value for OK interpolation, default = NULL
range	numeric describing distance beyond which there is no spatial correlation in Ordinary Kriging models, default = NULL
nugget	numeric describing variance at zero distance in Ordinary Kriging models, default = 0
kappa	numeric value describing model smoothness, default = NULL

Details

If 'res' and 'crsUnits' are specified (recommended), the output raster is returned in the original projection at the specified resolution. If 'res' and 'crsUnits' are not specified, 'fact' must be defined as a numeric value by which the resolution of the output DEM will be increased (1 = no change). Output raster will be returned in the original projection of the input.

For the model argument there are four different methods included here that are supported by gstat::vgm ("Sph", "Exp", "Gau", "Mat"). "Sph" = The default gstat::vgm method. Spherical model characterized by a curve that rises steeply to defined range then flattens, indicates no spatial correlation between points beyond that range. "Exp" = Exponential model characterized by spatial correlation decaying with distance. "Gau" = Gaussian model similar to spatial model but with stronger decay at shorter distances. "Mat" = Matern model Three parameters (psill, range, kappa) are incorporated from a fitted variogram (default = NULL). If specified in function input, chosen values will overwrite variogram values.

DEMs generated using OK method will have two layers; the first are the interpolated values and the second are the variances associated with each measurement

Value

DEM of waterbody bathymetry

Author(s)

Tristan Blechinger & Sean Bertalot, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load example outline
outline <- terra::vect(system.file("extdata", "example_outline.shp", package = 'rLakeHabitat'))
#load example xyz data
data <- read.csv(system.file("extdata", "example_depths.csv", package = 'rLakeHabitat'))
#run function
interpBathy(outline, data, "x", "y", "z", zeros = FALSE, separation = 10,
crsUnit = "dd", res = 5, method = "IDW", nmax = 4, idp = 2)
```

---

littoralVol *Calculate Littoral Volume*

Description

Calculate littoral and pelagic volume across water levels from a DEM based on estimated photic depth.

Usage

```
littoralVol(
  DEM,
  photic,
  secchi = NULL,
  DEMunits = "m",
  depthUnits = "ft",
  by = 1
)
```

Arguments

DEM	SpatRaster object of a given waterbody, rasters can be transformed to SpatRaster via the rast() function in 'terra'
photic	number giving the average photic depth, overwrites Secchi depth
secchi	number giving the average secchi depth, photic zone estimated as 2.6m * secchi
DEMunits	character describing units of raster coordinate system. Can be meters, kilometers, or hectares ("m", "km", "ha"), default = "m"
depthUnits	character describing units of depth measurement. Can be either feet or meters ("ft", "m"), default = "ft"
by	numeric increment per unit by which volumes are calculated. Higher values will result in lower resolution. Default = 1

Value

data frame of littoral and pelagic volume estimates

Author(s)

Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load raster
DEM <- terra::rast(system.file("extdata", "example_raster.tif", package = 'rLakeHabitat'))
#run function
littoralVol(DEM, photic = 2, DEMunits = "m", depthUnits = "m", by = 1)
```

---

rarify *Rarify Depth Data*

Description

Reduce density of mapped depth data to improve accuracy and computation time.

Usage

```
rarify(outline, df, x, y, z, res = 10, crsUnits = "dd")
```

Arguments

outline	shapefile outline of a waterbody
df	dataframe of coordinates and depths for a given waterbody
x	character giving name of longitude column
y	character giving name of latitude column
z	character giving name of depth column
res	number describing by how much to increase point resolution, default = 10
crsUnits	character describing CRS units of input outline, either "dd" (decimal degrees) or "m" (meters), default = "dd"

Value

dataframe of rarified xyz coordinates

Author(s)

Sean Bertalot & Tristan Blechinger, Department of Zoology & Physiology, University of Wyoming

Examples

```
#load test data
outline <- terra::vect(system.file("extdata", "example_outline.shp", package = 'rLakeHabitat'))
depths <- read.csv(system.file("extdata", "example_depths.csv", package = 'rLakeHabitat'))
#run function
rarify(outline = outline, df = depths, x = "x", y = "y", z = "z", res = 100, crsUnits = "dd")
```

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