Package ‘lakemorpho’

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Description Lake morphometry metrics are used by limnologists to understand, among other things, the ecological processes in a lake. Traditionally, these metrics are calculated by hand, with planimeters, and increasingly with commercial GIS products. All of these methods work; however, they are either outdated, difficult to reproduce, or require expensive licenses to use. The ‘lakemorpho’ package provides the tools to calculate a typical suite of these metrics from an input elevation model and lake polygon. The metrics currently supported are: fetch, major axis, minor axis, major/minor axis ratio, maximum length, maximum width, mean width, maximum depth, mean depth, shoreline development, shoreline length, surface area, and volume.

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R topics documented:

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**calcLakeMetrics**

**Description**

This function is a wrapper function for all of the metrics. It calculates each metric for an input lakeMorphoClass. This returns a list of all metrics.

**Usage**

calcLakeMetrics(inLakeMorpho, bearing, pointDens, correctFactor = 1)

**Arguments**

- **inLakeMorpho**
  an object of lakeMorphoClass. Output of the lakeSurroundTopo function would be appropriate as input.

- **bearing**
  Numeric that indicates the bearing of the desired fetch.

- **pointDens**
  Number of points to place equidistant along shoreline for lakeMaxLength or density of lines to test for lakeMaxWidth and lakeFetch.

- **correctFactor**
  Value used to correct the predicted maximum lake depth. Defaults to 1. Corrections are simply accomplished by multiplying estimated max depth by correction factor. Correction factors can be determined empirically by regressing the predicted depth against a known maximum depth while forcing the intercept through zero. The slope of the line would then be used as the correction factor (Hollister et. al, 2011).
exampleElev

**Value**

Returns a list with all lake metrics calculated for a given input lakemorpho object

**References**

Florida LAKEWATCh (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCh, Department of Fisheries and Aquatic Sciences. [Link](#)


**Examples**

```r
data(lakes)
calcLakeMetrics(inputLM,45,250)
```

---

**exampleElev**  |  *Elevation Data for lakemorpho examples*

**Description**

This example data is a RasterLayer of a small subset of the National Elevation Dataset named exampleElev.

**Format**

RasterLayer of 1094 x 1419 and 30 meter resolution

---

**exampleLake**  |  *Lake Data for lakemorpho examples*

**Description**

This example data is a SpatialPolygonsDataframe of lakes named exampleLakes. These lakes are originally from the NHDPlus V2 dataset.

**Format**

SpatialPolygonDataframe with 115 lakes, each with 13 variables
Description

This example lakemorpho class was generated using lakeSurroundTopo with the included exampleElev and exampleLake data.

Format

lakemorpho class

Description

The function calculates the maximum in lake distance of a line along an input bearing.

Usage

lakefetch(inlakemorpho, bearing, addLine = T)

Arguments

- **inLakeMorpho**: An object of lakeMorphoClass. Output of the lakeSurroundTopo function would be appropriate as input.
- **bearing**: Numeric that indicates the bearing of the desired fetch.
- **addLine**: Boolean to determine if the selected max length line should be added to the inLakeMorpho object. Defaults to True. Note that the line is returned in the same projection as the input data.

Value

Returns a numeric value indicating the length of the longest line in the lake along the input bearing. Units are the same as the input data.

References

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. Link

Examples

data(lakes)
lakefetch(inputLM,45)
**lakeMajorAxisLength**

Calculate the length of the major axis for lake

**Description**

Major axis length is defined as the maximum length spanning the convex hull of a lake.

**Usage**

```
lakeMajorAxisLength(inLakeMorpho, addLine = TRUE)
```

**Arguments**

- `inLakeMorpho` An object of `lakeMorphoClass`. Output of the `lakesurroundtopo` function would be appropriate as input
- `addLine` Boolean to determine if the selected major axis line should be added to the `inLakeMorpho` object. Defaults to True

**Value**

This returns a numeric value indicating the length of the major axis in the lake. Units are the same as the input data.

**References**

- Wikipedia

**Examples**

```r
data(lakes)
lakeMajorAxisLength(inputLM)
```

---

**lakeMaxDepth**

Estimate maximum lake depth

**Description**

This function uses slope and distance to estimate max depth. This is based on the assumption that the slope of the surrounding topography is similar to the bathymetry of the lake (Hollister et. al 2011).
lakeMaxLength

Usage

```r
lakeMaxDepth(inLakeMorpho, correctFactor = 1)
```

Arguments

- `inLakeMorpho`: An object of `lakeMorphoClass`. Output of the `lakesSurroundTopo` function would be appropriate as input.
- `correctFactor`: Value used to correct the predicted maximum lake depth. Defaults to 1. Corrections are simply accomplished by multiplying estimated max depth by correction factor. Correction factors can be determined empirically by regressing the predicted depth against a known maximum depth while forcing the intercept through zero. The slope of the line would then be used as the correction factor (Hollister et. al, 2011).

Value

Returns a numeric value of the predicted maximum depth.

References


Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. Link

Examples

```r
data(lakes)
lakeMaxDepth(inputLM)
```

```
lakeMaxLength  Calculate maximum lake length
```

Description

Maximum lake length is defined as the longest open water distance of a lake. This function determines the maximum lake length of lake by comparing the lengths of a user defined number of lines. The user specifies a number of points to distribute along the lake shoreline and the point to point line lengths are checked for multiple intersections (i.e. line not just open water), starting with the longest line first. Function is currently very sensitive to `pointDens` and slows down considerably for larger values. Small values of point dens are acceptable for lakes without complex shorelines. Care needs to be taken in selecting an appropriate `pointDens` and multiple values should be checked to ensure stability in the estimates.

Usage

```r
lakeMaxLength(inLakeMorpho, pointDens, addLine = T)
```
**Arguments**

- **inLakeMorpho** An object of `lakeMorphoClass`. Output of the `lakeSurroundTopo` function would be appropriate as input.
- **pointDens** Number of points to place equidistant along shoreline. The maximum point to point distance that does not also intersect the shoreline is used. To total of \(n^2(n-1)/2\) comparisons is possible, but in practice is usually significant less.
- **addLine** Boolean to determine if the selected max length line should be added to the `inLakeMorpho` object. Defaults to True.

**Value**

This returns a numeric value indicating the length of the longest line possible in the lake. Units are the same as the input data.

**References**

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. [Link](#)

**Examples**

```r
data(lakes)
lakeMaxLength(inputLM, 50)
```

---

**lakeMaxWidth**  
*Function to find line representing maximum lake Width*

**Description**

Maximum lake width is defined as the maximum in lake distance that is perpendicular to the maximum lake length. As no definition specifies whether or not the maximum lake width should intersect the line of maximum length, this function assumes that it does not, but may be forced to find the maximum width line that is perpendicular to and intersects with the maximum lake length line. This function calculates the equation of the perpendicular line and repeats that line `pointDens` number of times and returns the longest of those lines.

**Usage**

```r
lakeMaxWidth(inLakeMorpho, pointDens, intersect = FALSE, addLine = T)
```

**Arguments**

- **inLakeMorpho** An object of `lakeMorphoClass`. Output of the `lakeSurroundTopo` function would be appropriate as input.
- **pointDens** Number of points to place equidistant along the `lakeMaxLength`. A line that crosses at that point and extends from shore to shore is calculated.
**intersect**

Boolean to force max width to intersect the max length line. For many lakes this will return the same line.

**addLine**

Boolean to determine if the selected max length line should be added to the inLakeMorpho object. Defaults to True

**Value**

Returns a numeric value indicating the length of the longest line perpendicular to the maximum length line.

**References**

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. [Link](#)

**Examples**

```r
data(lakes)
lakeMaxWidth(inputLM, 50)
```

---

**lakeMeanDepth**

*Function to return lake Mean Depth*

**Description**

Calculates average depth of lake as a mean of lake volume divided by lake surface area

**Usage**

```r
lakeMeanDepth(inLakeMorpho, zmax = NULL)
```

**Arguments**

- `inLakeMorpho` An object of `lakeMorphoClass`. Output of the `lakeSurroundTopo` function would be appropriate as input
- `zmax` Maximum depth of the lake. If none entered and elevation dataset is included in inLakeMorpho, `lakeMaxDepth` is used to estimate a maximum depth.

**Value**

Returns a numeric value for the mean depth of the lake

**References**

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. [Link](#)
**lakeMeanWidth**

Examples

```r
data(lakes)
lakeMeanDepth(inputLM)
```

---

**lakeMeanWidth**  
*Function to return lake Mean Width*

---

**Description**

Mean lake width is the result of lake surface area divided by the maximum length.

**Usage**

```r
lakeMeanWidth(inLakeMorpho)
```

**Arguments**

- `inLakeMorpho`: An object of `lakeMorphoClass`. Output of the `lakeSurroundTopo` function would be appropriate as input

**Value**

Returns a numeric value for the mean width of the lake

**References**

Florida LAKEWATCH (2001). A Beginner's guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. [Link](#)

@import rgeos

Examples

```r
data(lakes)
lakeMaxLength(inputLM, 50)
lakeMeanWidth(inputLM)
```
lakeMinorAxisLength

*Calculate the length of the minor axis for lake*

**Description**

Minor axis length is defined as the minimum length spanning the convex hull of a lake.

**Usage**

```r
lakeMinorAxisLength(inputLM)
```

**Arguments**

- `inputLM` An object of `lakeMorphoClass`. Output of the `lakesurroundtopo` function would be appropriate as input.
- `addLine` Boolean to determine if the selected minor axis line should be added to the `inLakeMorpho` object. Defaults to `TRUE`.

**Value**

This returns a numeric value indicating the length of the minor axis in the lake. Units are the same as the input data.

**References**

Wikipedia

**Examples**

```r
data(lakes)
lakeMinorAxisLength(inputLM)
```

lakeMinorMajorRatio

*Calculate the ratio of the minor axis length to major axis length*

**Description**

Major axis length is defined as the maximum length spanning the convex hull of a lake. Minor axis length is defined as the minimum length spanning the convex hull of a lake.

**Usage**

```r
lakeMinorMajorRatio(inputLM)
```

**Arguments**

- `inputLM` An object of `lakeMorphoClass`. Output of the `lakesurroundtopo` function would be appropriate as input.
- `addLine` Boolean to determine if the selected minor axis line should be added to the `inLakeMorpho` object. Defaults to `TRUE`.

**Value**

This returns a numeric value indicating the ratio of the minor axis length to major axis length. Units are the same as the input data.
Arguments

inLakeMorpho  An object of lakeMorphoClass. Output of the lakeSurroundTopo function would be appropriate as input
addLine  Boolean to determine if the selected major and minor axis lines should be added to the inLakeMorpho object. Defaults to True

Value

This returns a vector of numeric values indicating the length of the major and minor axes of the lake. Units are the same as the input data.

Examples

data(lakes)
lakeMinorMajorRatio(inputLM)

Description

Lakemorpho provides a number of functions to calculate a standard suite of lake morphometry metrics. Most of the metrics are measurements of the shape of the lake. Metrics that rely on depth have traditionally been calculated with bathymetry data. In the absence of bathymetry data it is possible to estimate maximum depth from surrounding topography. Lakemorpho uses this approach to also estimate maximum depth, mean depth, and volume.

Details

This development version of this package is available at https://github.com/USEPA/lakemorpho

References

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. Link
Description

This is a helper function that creates a lakeMorpho class object

Usage

lakemorphoclass(inLakeLine = NULL, inCatch = NULL, inLakeDist = NULL, lakeOnEdge = F)

Arguments

inLake input lake SpatialPolygons object. Required.
inElev input elevation model raster object
inCatch input catchement SpatialPolygons object, can be buffer around lake
inLakeDist input euclidean distance raster that measures distance from shore to any pixel in the lake
lakeOnEdge Boolean indicating if inCatch (or lake Buffer) extends beyond extent of elevation data

Value

Returns an object of class 'lakeMorpho'

See Also

lakeSurroundTopo

lakeShorelineDevelopment

Description

Shoreline development is a measure of the complexity of the lake shoreline. It is simply the ratio of the shoreline length (i.e. perimeter) to the perimeter of an equally sized circle.

Usage

lakeshorelinedevelopment(inLakeMorpho)
lakeShorelineLength

Arguments

inLakeMorpho An object of lakeMorphoClass. Output of the lakeSurroundTopo function would be appropriate as input

Value

Returns a numeric value for the shoreline development of the lake

References

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. Link

Examples

data(lakes)
lakeShorelineDevelopment(inputLM)


data(lakes)
lakeShorelineLength(inputLM)

Description

This function returns the length of the shoreline of the lake and is simply the perimeter of the input lake polyogn.

Usage

lakeShorelineLength(inLakeMorpho)

Arguments

inLakeMorpho An object of lakeMorphoClass. Output of the lakeSurroundTopo function would be appropriate as input

Value

Returns a numeric value for the length of the lake shoreline

References

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. Link

Examples

data(lakes)
lakeShorelineLength(inputLM)
### lakeSurfaceArea

**Return lake surface area**

**Description**

This function simply returns the area of the lake SpatialPolygons that is part of the `lakeMorphoClass` class.

**Usage**

```r
lakeSurfaceArea(inLakeMorpho)
```

**Arguments**

- `inLakeMorpho`: an object of `lakeMorphoClass`. Output of the `lakeSurroundTopo` function would be appropriate as input.

**Value**

Returns a numeric value for the total surface area of the lake.

**References**

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. [Link](#)

**Examples**

```r
data(lakes)
lakeSurfaceArea(inputLM)
```

---

### lakeSurroundTopo

**Calculate surrounding topography for lake**

**Description**

This function combines all input datasets into a `lakeMorphoClass`. As a part of this combination, the surrounding topography is also determined. If no input catchments are used, it is assumed that a buffer equal to the maximum in lake distance is used. If an input catchment is used, then the surrounding topography is the land area represented by the catchments that intersect the lake. This function (and all of `lakemorpho`) expect clean polygons. No internal checking (e.g. for proper encoding of holes, etc.) is done.

**Usage**

```r
lakeSurroundTopo(inLake, inElev, inCatch = NULL, reso = res(inElev)[1])
```
lakeVolume

Arguments

inLake a SpatialPolygons or SpatialPolygonsDataFrame representing the input lake. Required.
inElev a RasterLayer representing the elevation around the lake. Required.
inCatch Optional SpatialPolygons or SpatialPolygonsDataFrame defining the Surrounding Topography. Default is NULL which uses a buffer equal to the maximum in lake distance.
reso Optional resolution for raster output (e.g. lake distance). Defaults to the resolution of inElev

Value

Returns an object of class 'lakemorpho' that includes the surrounding topography of the lake.

Examples

data(lakes)
inputLM<-lakesurroundtopo(exampleLake,exampleElev)
inputLM

lakeVolume Calculates Lake Volume in R

Description

This function returns lake volume for the input lake. The volume is calculated using maximum lake depth and maximum distance ratio to transform all pixels and thus, distances, to an estimated depth. These depths are multiplied by the area of the pixel and summed.

Usage

lakeVolume(inLakeMorpho, zmax = NULL, correctFactor = 1)

Arguments

inLakeMorpho An object of lakeMorphoClass. Output of the lakesurroundTopo function would be appropriate as input
zmax Maximum depth of the lake. If none entered and elevation dataset is included in inLakeMorpho, lakeMaxDepth is used to estimate a maximum depth.
correctFactor This a factor used by lakeMaxDepth to correct the predicted maximum lake depth. Defaults to 1.
Value

Returns a numeric value for the total volume of the lake

References

Florida LAKEWATCH (2001). A Beginner’s guide to water management - Lake Morphometry (2nd ed.). Gainesville: Florida LAKEWATCH, Department of Fisheries and Aquatic Sciences. Link

Examples

data(lakes)
lakeVolume(inputLM)

plot.lakeMorpho

Default plotting of a lakeMorpho object

Description

Plots the lakeMorpho class by showing lake, surround topography and in lake distance

Usage

## S3 method for class 'lakeMorpho'
plot(x, dist = FALSE, length = TRUE, width = TRUE, fetch = FALSE, ...)

Arguments

x input lakeMorpho class to plot
dist Boolean to control plotting of in lake distance
length Boolean to control plotting of max lake length line
width Boolean to control plotting of max lake width line
fetch Boolean to control plotting of fetch lines
... allows for passing of other plot parameters

Examples

data(lakes)
plot(inputLM)
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