Package ‘compInd’

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Contents

`compInd-package` *compInd: Forest tree-tree competition indices*

Details

A collection of functions drawn from the academic literature used in forests to quantify tree-tree competition.

Author(s)

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`alemdag` *Alemdag's (1978) tree competition index*

Description

Alemdag's (1978) tree competition index

Usage

```
alemdag(dbh, dist, focal_dbh)
```

Arguments

`dbh`	vector of DBH (diameter at breast height) measurements of competitor trees
`dist`	vector of distances from focal tree to competitor trees
`focal_dbh`	DBH of focal tree

Details

A spatially explicit competition index originally used in white spruce plantations. The value of this function increases when competitor trees are closer to the focal tree, or when competitor trees are larger. Alemdag's competition index is defined by the following equation:

$$\sum_{j \neq i}^{n} (\pi[(l_{ij} d_i)/(d_i + d_j)]^2 (d_j/l_{ij})/\sum(d_j/l_{ij}))$$

where l_{ij} is the distance between focal tree i and competitor tree j, and d_i is the diameter (DBH) of focal tree i.

Value

value of competition index for focal tree

References

Alemdag I. S. (1978). Evaluation of some competition indexes for the prediction of diameter increment in planted white spruce. Forest Management Institute, Ottawa, Canada.

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 4)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  focal_diam <- unique(bicuar[bicuar$stem_id == nb$focal,"diam"])
  alemdag(nb$diam, nb$nb_dist, focal_diam)
  })
```

`angleCalc` *Calculate angle between two sf point objects*

Description

Calculate angle between two sf point objects

Usage

```
angleCalc(x, y)
```

Arguments

x	numeric vector with two elements, X and Y coordinates of a point
y	numeric vector with two elements, X and Y coordinates of a point

Value

azimuthal from x to y, in degrees

Examples

```
p1 <- c(0, 1)
p2 <- c(1, 2)
angleCalc(p1, p2)
```

baLarger — *Basal area of larger trees - Wykoff et al. 1982*

Description

Basal area of larger trees - Wykoff et al. 1982

Usage

```
baLarger(ba, focal_size, size)
```

Arguments

`ba`	vector of basal area of competitor trees
`focal_size`	size of subject tree
`size`	vector of sizes of competitor trees

Details

Returns the sum of basal areas of all trees larger than the focal tree. In Wykoff et al. (1982), `size` is basal area, though other measures of size could be used such as tree height (e.g. Flake et al. 2022).

Value

value of competition index for focal tree

References

Wykoff, W. R., Crookston, N. L., Stage, A. R. (1982). User's guide to the stand prognosis model. United States Department of Agriculture Forest Service. Ogden UT, USA.

baLocal — *Total basal area of competitor trees - Steneker and Jarvis 1963*

Description

Total basal area of competitor trees - Steneker and Jarvis 1963

Usage

```
baLocal(ba)
```

Arguments

`ba`	vector of basal area of competitor trees

Details

Included mainly for posterity, simply the sum of basal areas of all competitor trees.

Value

value of competition index for focal tree

References

Steneker, G.A.; Jarvis, J.M. (1963). A preliminary study to assess competition in a white spruce-trembling aspen stand. Forestry Chronicle. Volume 39. Issue 3. Pages 334-336.

`basalArea` *Calculate basal area from DBH*

Description

Calculate basal area from DBH

Usage

```
basalArea(x)
```

Arguments

`x`	numeric vector of DBH values

Value

numeric vector of basal area values

Examples

```
a <- c(1.23, 5.67, 10.11)
basalArea(a)
```

`bicuar` *Tree stem data from a 1 ha woodland plot in Bicuar National Park, Angola*

Description

Tree stem data from a 1 ha woodland plot in Bicuar National Park, Angola

Usage

```
data(bicuar)
```

Format

An object of class `data.frame` with 460 rows and 6 columns.

clarkEvans *Clark-Evans index of neighbourhood pattern*

Description

Clark-Evans index of neighbourhood pattern

Usage

```
clarkEvans(x, area)
```

Arguments

x	two column matrix of individual x and y coordinates
area	area of the plot, in the same units as x and y coordinates

Details

Essentially the sum of nearest neighbour distances of all individuals in the plot, normalised by the density of individuals in the plot. Bounded between 0 and 2.15, with values <1 indicating a clustered distribution. A completely regular hexagonal distribution results in the highest value of 2.15.

Value

Value of the competition index for the structural unit, i.e. plot.

References

Clark, F. J., Evans, F. C. (1954). Distance to the nearest neighbour as a measure of spatial relationships in populations. Ecology. Volume 35. Pages 445-453

Examples

```
data(bicuar)
clarkEvans(bicuar[,c("x", "y")], 10000)
```

crowdInd *Forest matrix crowding index - Seydack et al. 2011*

Description

Forest matrix crowding index - Seydack et al. 2011

Usage

```
crowdInd(dbh, dbh_min = 10, dbh_max = 30)
```

Arguments

`dbh`	vector of DBH (diameter at breast height) measurements of competitor trees
`dbh_min`	minimum DBH threshold considered
`dbh_max`	maximum DBH threshold considered

Details

A simple competition index which returns the sum of DBH values of all competitor trees within user-defined DBH thresholds. Armin et al. (2011) use a minimum threshold of 10 cm DBH and a maximum threshold of 30 cm DBH.

Value

value of competition index for focal tree

References

Armin H.W. Seydack, Graham Durrheim, Josua H. Louw. Spatiotemporally interactive growth dynamics in selected South African forests: Edaphoclimatic environment, crowding and climate effects. Forest Ecology and Management. Volume 261. Issue 7. 2011. Pages 1152-1169.

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 4)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  crowdInd(nb$diam, dbh_min = 10, dbh_max = 30)
  })
```

`dataGen` *Generate fake data from a rectangular tree plot*

Description

Generate fake data from a rectangular tree plot

Usage

```
dataGen(
  nplots = 5,
  min_stems = 200,
  max_stems = 500,
  min_diam = 5,
  max_diam = 100,
  plot_width = 100,
  plot_length = plot_width,
  species = LETTERS[1:20]
)
```

Arguments

`nplots`	number of plots
`min_stems`	minimum number of stems per plot
`max_stems`	maximum number of stems per plot
`min_diam`	minimum stem diameter
`max_diam`	maximum stem diameter
`plot_width`	plot width
`plot_length`	plot length
`species`	vector of species names from which to sample

Value

dataframe, where each row is a tree stem. Default of five plots, each with between 200 and 500 stems, from 20 species, with stem diameter values between 5 and 100. All trees have a single stem. Diameter values are drawn from a uniform distribution. Stem locations and species are randomly sampled, with repeats.

Examples

```
dat <- dataGen()
dat2 <- dataGen(nplots = 1, min_stems = 10, max_stems = 50, dbh_min = 10,
  dbh_max = 200, plot_width = 20, plot_length = 50,
  sp = c("Burkea africana", "Ochna pulchra"))
```

---

dbhCorr *Diameter correlation index - Davies 2008*

Description

Diameter correlation index - Davies 2008

Usage

```
dbhCorr(dbh, focal_dbh)
```

Arguments

`dbh`	vector of DBH (diameter at breast height) measurements of competitor trees
`focal_dbh`	DBH of focal tree

Details

All else being equal, the value of `diamCorr()` increases as the focal tree size increases. For a given focal tree size, the value increases as average neighbour size increases. Given by the equation:

$$DCI_i = \frac{dbh_i \sum_{j=1}^{n} dbh_j}{n\overline{dbh}^2}$$

Value

value of competition index for focal tree

References

Davis, O., Pommerening, A. (2008). The contribution of structural indices to the modelling of Sitka spruce (Picea sitchensis) and birch (Betula spp.) crowns. Forest Ecology and Management. Volume 256. Pages 68-77.

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 4)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  focal_diam <- unique(bicuar[bicuar$stem_id == nb$focal,"diam"])
  dbhCorr(nb$diam, focal_diam)
  })
```

---

dbhDiff *DBH differentiation - Pommerening 2002*

Description

DBH differentiation - Pommerening 2002

Usage

```
dbhDiff(dbh, focal_dbh)
```

Arguments

dbh	vector of dbh (diameter at breast height) measurements of competitor trees
focal_dbh	dbh of focal tree

Details

Gives the size difference of neighbouring trees and describes the spatial distribution of tree sizes. The value increases with increasing average size difference between neighbouring trees. `dbhDiff == 0` when all neighbours have equal size.

Value

value of competition index for focal tree

References

Pommerening, A. (2002). Approaches to quantifying forest structures. Forestry, Volume 75, Issue 3. Pages 305-324.

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 4)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  focal_diam <- unique(bicuar[bicuar$stem_id == nb$focal,"diam"])
  dbhDiff(nb$diam, focal_diam)
  })
```

---

dbhDom *DBH dominance - Aguirre et al. 2003*

Description

DBH dominance - Aguirre et al. 2003

Usage

```
dbhDom(dbh, focal_dbh)
```

Arguments

`dbh`	vector of dbh (diameter at breast height) measurements of competitor trees
`focal_dbh`	dbh of focal tree

Details

Gives the proportion of the n nearest neighbours which are smaller than the focal tree.

Value

value of competition index for focal tree

References

Aguirre, O., Hui, G., von Gadow, K., Jimenez, J. (2003). An analysis of spatial forest structure using neighbourhood-based variables. Forest Ecology and Management. Volume 183. Pages 13.

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 4)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  focal_diam <- unique(bicuar[bicuar$stem_id == nb$focal,"diam"])
  dbhDom(nb$diam, focal_diam)
  })
```

domConInd — *Dominance concentration index (Su et al. 2020)*

Description

Dominance concentration index (Su et al. 2020)

Usage

```
domConInd(ba, sp)
```

Arguments

ba	vector of basal area measurements of competitor trees
sp	vector of individual species names

Value

value of dominance concentration index for focal tree

References

Su S., Guan B. T., Chang-Yang C., Sun I., Wang H., Hsieh C. (2020). Multi-stemming and size enhance survival of dominant tree species in a frequently typhoon-disturbed forest. Journal of Vegetation Science 31(3), pp. 429-439. DOI: 10.1111/jvs.12858

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 10)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  nb$ba <- basalArea(nb$diam)
  domConInd(nb$ba, nb$sp)
  })
```

edgeExclude — *Find individuals inside a buffer zone away from the plot edge*

Description

Find individuals inside a buffer zone away from the plot edge

Usage

```
edgeExclude(x, buffer, xmin, xmax, ymin, ymax)
```

Arguments

`x`	two column matrix of individual x and y coordinates
`buffer`	size of buffer zone inside plot, same scale as coordinates `xmin`, `xmax`, `ymin`, `ymax`
`xmin`	minimum x coordinate in plot
`xmax`	maximum x coordinate in plot
`ymin`	minimum y coordinate in plot
`ymax`	maximum y coordinate in plot

Details

Generally, the buffer size should be the same size as the expected competition zone radius around each tree, to ensure that the value of a given competition index isn't under-estimated for trees near the plot edge, due to a lack of data collected outside the plot. For example, if the competition radius set by `nearNeighb` is 5 m, the buffer should also be 5 m. Trees within the buffer zone are generally excluded as focal trees in competition indices, but may still be used as competitor trees by other focal trees not inside the buffer zone.

Value

vector of rows from `x` which are not within the buffer zone.

Examples

```
data(bicuar)
edgeExclude(bicuar[,c("x", "y")], 5, 0, 100, 0, 100)
```

---

hegyi *Hegyi index - Hegyi 1974*

Description

Hegyi index - Hegyi 1974

Usage

```
hegyi(dbh, dist, focal_dbh)
```

Arguments

`dbh`	vector of DBH (diameter at breast height) measurements of competitor trees
`dist`	vector of distances from focal tree to competitor trees
`focal_dbh`	DBH of focal tree

Details

A spatially explicit competition index which takes into account DBH and distance of competitor trees. The iterative Hegyi index is a variant which picks competitors based on minimum distance of neighbouring trees within arc zones around the focal tree.

Value

value of competition index for focal tree

References

Hegyi, F., 1974. A simulation model for managing jack-pine stands. In: Fries, J. (Ed.), Growth Models for Tree and Stand Simulation. Royal College of Forestry, Stockholm, pages. 74–90.

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 4)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  focal_diam <- unique(bicuar[bicuar$stem_id == nb$focal,"diam"])
  hegyi(nb$diam, nb$nb_dist, focal_diam)
  })
```

---

lorimerComp *Lorimer's competition index - Lorimer 1983*

Description

Lorimer's competition index - Lorimer 1983

Usage

```
lorimerComp(dbh, dist, focal_dbh, czr)
```

Arguments

`dbh`	vector of DBH (diameter at breast height) measurements of competitor trees
`dist`	vector of distances from focal tree to competitor trees
`focal_dbh`	DBH of focal tree
`czr`	Competition zone radius (CZR), normally based on plot-level stem density

Details

Value increases with dbh of competitor trees, decreases as the focal tree DBH increases. Value increases as the distance of competitor trees decreases. Tree distances are divided by the CZR in order to account for "stand age".

Value

value of competition index for focal tree

References

Lorimer, C. G. (1983). Tests of age-independent competition indices for individual trees in natural hardwood stands. Forest Ecology and Management. Volume 6. Pages 343-360.

See Also

lorimerCZR() to calculate the CZR

Examples

```
data(bicuar)
czr <- lorimerCZR(k = 1, n = nrow(bicuar))
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, radius = czr)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id", all.x = TRUE)
  focal_diam <- unique(bicuar[bicuar$stem_id == unique(nb$focal),"diam"])
  lorimerComp(nb$diam, nb$nb_dist, focal_diam, czr)
  })
```

---

lorimerCZR *Lorimer's Competition Zone Radius - Lorimer 1983*

Description

Lorimer's Competition Zone Radius - Lorimer 1983

Usage

```
lorimerCZR(k, n)
```

Arguments

k	constant, usually 0.4
n	number of trees per hectare

Details

Estimates the competition zone radius, based on the number of trees per hectare in the plot multiplied by a constant (k).

Value

value of competition zone radius

References

Lorimer, C. G. (1983). Tests of age-independent competition indices for individual trees in natural hardwood stands. Forest Ecology and Management. Volume 6. Pages 343-360.

Examples

```
data(bicuar)
lorimerCZR(1, nrow(bicuar))
```

`martinEk` *Martin and Ek 1984*

Description

Martin and Ek 1984

Usage

```
martinEk(dbh, dist, focal_dbh)
```

Arguments

`dbh`	vector of DBH (diameter at breast height) measurements of competitor trees
`dist`	vector of distances from focal tree to competitor trees
`focal_dbh`	DBH of focal tree

Details

Gives the sum of ratios of competitor to focal tree DBHs, multiplied by the exponential of distances divided by competitor DBH plus focal DBH. Given by the equation:

$$\sum_{j \neq i}^{n} (d_j/d_i)exp((16l_{ij})/(d_i + d_j))$$

Value

value of competition index for focal tree

References

Martin G. L., Ek A. R. (1984). A Comparison of Competition Measures and Growth Models for Predicting Plantation Red Pine Diameter and Height Growth. Forest Science. Volume 30. Pages 731-743.

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 4)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  focal_diam <- unique(bicuar[bicuar$stem_id == nb$focal,"diam"])
  martinEk(nb$diam, nb$nb_dist, focal_diam)
  })
```

`nearNeighb` *Find nearest neighbours within a radius*

Description

Find nearest neighbours within a radius

Usage

```
nearNeighb(x, y = NULL, k = NULL, radius = NULL, zones = NULL)
```

Arguments

`x`	two column matrix of individual x and y coordinates
`y`	optional two column matrix of individual x and y coordinates
`k`	number of neighbours to search for, starting from nearest in coordinate space. If NULL, `radius` must be provided.
`radius`	radius to look for nearest neighbours, in units of XY coordinates. If `NULL`, `k` must be provided.
`zones`	number of zones of equal arc angle, e.g. `zones = 4` results in four zones each with 90deg arc. If `NULL`, no zones are defined. If zones are defined, the nearest competitor within each zone is returned. If zones are defined, `radius` must also be defined.

Details

If `y` is provided, nearest neighbours of individuals in `y` are identified for each individual in `x`, otherwise, nearest neighbours in `x` are identified.

In the case of ties, the first nearest neighbour is returned.

Value

List of dataframes per focal individual in x, of neighbours, their distances and angles relative to the focal individual. If no competitors are found within the radius of a focal individual, NA is returned for all columns except focal ID.

Examples

```
data(bicuar)

nearNeighb(bicuar[,c("x", "y")], k = 4)
nearNeighb(bicuar[1:10, c("x", "y")], bicuar[, c("x", "y")], radius = 5)
nearNeighb(bicuar[,c("x", "y")], radius = 5, zones = 4)
```

`pielou` *Pielou's index of non-randomness*

Description

Pielou's index of non-randomness

Usage

```
pielou(x, xmin, xmax, ymin, ymax, k)
```

Arguments

`x`	two column matrix of individual x and y coordinates
`xmin`	minimum x coordinate in plot
`xmax`	maximum x coordinate in plot
`ymin`	minimum y coordinate in plot
`ymax`	maximum y coordinate in plot
`k`	number of randomly allocated sample points

Details

The sum of squared nearest neighbour distances normalised by the number of sample points and the number of individuals in the structural unit. Defined by the equation:

$$\pi \frac{n}{A} \frac{1}{k} \sum_{1}^{k} r_i^2$$

where n is the number of individuals in the structural unit, A is the structural unit area, k is the number of sample points, and r_i is the nearest neighbour distance to individual i.

As the sample points are randomly allocated within the bounds of xmin,xmax,ymin,ymax, the mean of a number of runs of this function could be used to further constrain the estimate of Pielou's index.

Value

value of the competition index for the structural unit, i.e. plot.

References

Pielou, E. C. (1959). The use of point to plant distances in the study of the pattern of plan populations. Journal of Ecology. Volume 47. Pages 607-613.

Examples

```
data(bicuar)
pielou(bicuar[,c("x", "y")], 0, 100, 0, 100, 50)
```

`pointDens` *Point density - Spurr (1962)*

Description

Point density - Spurr (1962)

Usage

```
pointDens(dbh, dist)
```

Arguments

`dbh`	vector of DBH (diameter at breast height) measurements of competitor trees
`dist`	vector of distances from focal tree to competitor trees

Details

Calculates point density in units of `dist`, with the equation:

$$\sum_{k=i}^{n}(0.25(k-0.5)(D_k/L_k)^2)/k$$

where k is the rank of the kth competitor by dbh value, D_k is the dbh of the kth competitor, and L_k is the distance of the kth competitor to the focal tree i.

Value

value of competition index for focal tree

References

Spurr, S. H. (1962). A measure of point density. Forest Science. Volume 8. Issue 1. Pages 85–96.

Examples

```
data(bicuar)
nb <- nearNeighb(bicuar$x, bicuar$y, bicuar$stem_id, k = 4)
lapply(nb, function(x) {
  nb <- merge(x, bicuar, by.x = "nb", by.y = "stem_id")
  pointDens(nb$diam, nb$nb_dist)
  })
```

`spatialMingling` *von Gadow's spatial mingling index*

Description

von Gadow's spatial mingling index

Usage

```
spatialMingling(x, sp, k = 4, adj = FALSE)
```

Arguments

`x`	two column matrix of individual x and y coordinates
`sp`	vector of individual species names
`k`	number of neighbours to consider
`adj`	logical, if `TRUE` the basic spatial mingling index is multiplied by $\frac{S_i}{n_{max}}$, where S_i is the number of species in the neighbourhood of the focal individual, and n_{max} is the maximum number of species possible in the neighbourhood, including the focal individual, i.e. $k + 1$.

Details

Describes the degree of variety in species in the vicinity of a given focal individual. The proportion of the k nearest neighbours not belonging to the same species as the focal individual, given by the equation:

$$\frac{1}{k}\sum_{j=1}^{k} v_j$$

where v_j is the status of the competitor individual j, either 0 if j belongs to the same species as the focal individual, or 1 if j belongs to a different species. Values of spatial mingling for a given individual therefore vary between 0 and 1.

As per von Gadow and Hui (2001) this function could be adapted to calculate spatial mingling as a point attribute rather than an individual attribute.

Normally expressed as the mean of values per structural unit to scale up.

Value

value of the spatial mingling index for each individual in the structural unit.

References

von Gadow, K., Hui, G. Y. (2001). Characterising forest spatial structure and diversity. Sustainable Forestry in Temperate Regions. Proc. of an international workshop organized at the University of Lund, Sweden. Pages 20-30.

Examples

```
data(bicuar)
spatialMingling(bicuar[, c("x", "y")], bicuar$species,
  k = 4, adj = FALSE
)
spatialMingling(bicuar[, c("x", "y")], bicuar$species,
  k = 4, adj = TRUE
)
```

---

winkelmass *Calculate the Winkelmass (spatial regularity of individuals)*

Description

Calculate the Winkelmass (spatial regularity of individuals)

Usage

```
winkelmass(x, k = 4)
```

Arguments

x	two column matrix of individual x and y coordinates
k	number of neighbours to consider

Details

literally in German, the 'angle measure', describes the degree of spatial regularity of individuals surrounding a given focal individual. The angle between each sequential neighbour with reference to the focal tree is calculated. As per the equation:

$$\frac{1}{k}\sum_{j=1}^{k} v_j$$

where v_j is 1 if the angle (α) between neighbours is less than the critical angle, i.e. $\alpha \leq \frac{360}{k}$, or 0 otherwise. As per von Gadow and Hui (2001) this function could be adapted to calculate regularity as a point attribute rather than an individual attribute.

As per von Gadow and Hui (2001) this function could be adapted to calculate spatial mingling as a point attribute rather than an individual attribute.

Normally expressed as the mean of values per structural unit to scale up.

Value

value of the competition index for each individual in the structural unit, i.e. plot.

References

von Gadow, K., Hui, G. Y. (2001). Characterising forest spatial structure and diversity. Sustainable Forestry in Temperate Regions. Proc. of an international workshop organized at the University of Lund, Sweden. Pages 20-30.

Examples

```
data(bicuar)
winkelmass(bicuar[,c("x", "y")], 4)
```

Index