Package 'timbeR'

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Title Calculate Wood Volumes from Taper Functions

Version 2.0.1

Description Functions for estimation of wood volumes, number of logs, diameters along the stem and heights at which certain diameters occur, based on taper functions and other parameters. References: McTague, J. P., & Weiskittel, A. (2021). <doi:10.1139/cjfr-2020-0326>.

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Imports dplyr, ggplot2, cowplot, tidyr, tibble, magrittr, miniUI, shiny

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Contents

`bi_di` *Estimate the diameter at a given height based on a fitted Bi (2000) taper equation.*

Description

Estimates the diameter at a given height of a tree from the diameter at breast height, total height and the coefficients of the Bi taper function.

Usage

```
bi_di(dbh, h, hi, coef)
```

Arguments

`dbh`	tree diameter at breast height, in centimeters.
`h`	total tree height, in meters.
`hi`	height at which the diameter will be calculated, in meters.
`coef`	numerical vector containing seven coefficients of the Bi taper function.

Details

the Bi (2000) variable-form taper function is represented mathematically by the following expression

di ~ dbh * (log(sin((pi/2) * (hi/h)))/(log(sin((pi/2) * (1.3/h)))))^(b0 + b1 * sin((pi/2) * (hi/h)) + b2 * cos((3 * pi/2) * (hi/h)) + b3 * (sin((pi/2) * (hi/h))/(hi/h)) + b4 * dbh + b5 * (hi/h) * dbh^0.5 + b6 * (hi/h) * h^0.5)

Value

a numeric value indicating the diameter at the given height.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

bi <-  nlsLM(di ~ taper_bi(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6),
data=tree_scaling,
start=list(b0=1.8,b1=-0.2,b2=-0.04,b3=-0.9,b4=-0.0006,b5=0.07,b6=-.14))

coef_bi <- coef(bi)

dbh <- 25
h <- 20
hi <- 15

bi_di(dbh, h, hi, coef_bi)
```

`bi_hi` *Estimate the height at which a given diameter occurs in a tree, based on a fitted Bi (2000) taper equation.*

Description

Estimates the height at which a given diameter occurs in a tree, from the diameter at breast height, total height and coefficients of the Bi taper function.

Usage

```
bi_hi(dbh, h, di, coef)
```

Arguments

`dbh`	tree diameter at breast height, in centimeters.
`h`	total tree height, in meters.
`di`	diameter whose height of occurrence will be estimated, in centimeters.
`coef`	numerical vector containing seven coefficients of the Bi taper equation

Details

the Bi (2000) variable-form taper function is represented mathematically by the following expression

di ~ dbh * (log(sin((pi/2) * (hi/h)))/(log(sin((pi/2) * (1.3/h)))))^(b0 + b1 * sin((pi/2) * (hi/h)) + b2 * cos((3 * pi/2) * (hi/h)) + b3 * (sin((pi/2) * (hi/h))/(hi/h)) + b4 * dbh + b5 * (hi/h) * dbh^0.5 + b6 * (hi/h) * h^0.5)

Value

a numeric value indicating the height at which the given diameter occurs.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

bi <-  nlsLM(di ~ taper_bi(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6),
data=tree_scaling,
start=list(b0=1.8,b1=-0.2,b2=-0.04,b3=-0.9,b4=-0.0006,b5=0.07,b6=-.14))

coef_bi <- coef(bi)

dbh <- 25
h <- 20
di <- 5

bi_hi(dbh, h, di, coef_bi)
```

---

bi_logs *Simulate log extraction using a Bi (2000) variable-form taper equation that describes the taper of the tree.*

Description

Simulate the extraction of logs from a tree from its measurements, taper function (Bi (2000) variable-form taper equation), trunk quality characteristics and harvest parameters such as stump height and assortments.

Usage

```
bi_logs(
  dbh,
  h,
  coef,
  assortments,
  stump_height,
  downgrade,
  broken,
  defect_height,
  eliminate,
```

```
  total_volume,
  only_vol
)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
coef	numerical vector containing seven coefficients of the Bi taper equation.
assortments	a data.frame with five columns and n rows, where n is the number of different wood assortments to be obtained from the tree stem. The first column must contain the names of the assortments, the second, numerical, contains the minimum diameters at the small end of the logs, in centimeters. The third column, numerical, contains the minimum lengths of the logs, in meters. The fourth column, numerical, contains the maximum lengths of the logs, in meters. The fifth column, numerical, contains the values in centimeters referring to the loss of wood due to cutting logs. The algorithm prioritizes the extraction of assortments along the stem in the order presented in the data.frame, starting from the first line, to the last.
stump_height	tree cutting height, in meters. Default is 0.
downgrade	if TRUE, the algorithm,from the defect_height onwards, simulates log extraction only for the last assortment in the assortments data.frame. Default is FALSE.
broken	if TRUE, the algorithm will simulate the extraction of logs only up to the defect_height. Default is FALSE.
defect_height	the height, in meters, from which the logs will be downgraded (if downgrade is TRUE) or log extraction simulation will be stopped (if broken is TRUE). Default is 0 for downgrade = TRUE (the whole tree is downgraded) and h * 0.5 for broken = TRUE (the tree is broken from half its original/estimated total height).
eliminate	if TRUE, the algorithm does not get logs for any assortment present in the assortments table. All will be zero. Default is FALSE.
total_volume	if TRUE, it adds an additional column to the results data.frame with the estimate of the total volume of the tree, from the ground height to h if broken argument is FALSE, or to defect_height if broken is TRUE. Default is FALSE.
only_vol	if TRUE returns only volumes (does not return the number of logs). Default is FALSE.

Details

when the broken and downgrade arguments are set to TRUE, the defect_height value is considered as the break height of the tree, and the entire tree is downgraded.

Value

a list of two data.frames, the first (volumes) with the calculated volumes per assortment, and the second (logs) with the number of logs per assortment.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

bi <-  nlsLM(di ~ taper_bi(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6),
data=tree_scaling,
start=list(b0=1.8,b1=-0.2,b2=-0.04,b3=-0.9,b4=-0.0006,b5=0.07,b6=-.14))

coef_bi <- coef(bi)

dbh <- 25
h <- 20

assortments <- data.frame(
  NAME = c('15-25','4-15'),
  SED = c(15,4),
  MINLENGTH = c(2.65,2),
  MAXLENGTH = c(2.65,4.2),
  LOSS = c(5,5)
)

bi_logs(dbh, h, coef_bi, assortments)
```

`bi_logs_plot` *Visualize the simulation of log cutting along the stem using a Bi (2000) variable-form taper equation.*

Description

Plot the shape of the tree and visualize the extracted logs based on the tree measurements, assortments data.frame, and the Bi (2000) variable-form taper equation.

Usage

```
bi_logs_plot(
  dbh,
  h,
  coef,
  assortments,
  stump_height,
  downgrade,
  broken,
  defect_height,
```

```
  lang
)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
coef	numerical vector containing seven coefficients of the Bi variable-form taper equation.
assortments	a data.frame with five columns and n rows, where n is the number of different wood assortments to be obtained from the tree stem. The first column must contain the names of the assortments, the second, numerical, contains the minimum diameters at the small end of the logs, in centimeters. The third column, numerical, contains the minimum lengths of the logs, in meters. The fourth column, numerical, contains the maximum lengths of the logs, in meters. The fifth column, numerical, contains the values in centimeters referring to the loss of wood due to cutting logs. The algorithm prioritizes the extraction of assortments along the stem in the order presented in the data.frame, starting from the first line, to the last.
stump_height	tree cutting height, in meters. Default is 0.
downgrade	if TRUE, the algorithm,from the defect_height onwards, simulates log extraction only for the last assortment in the assortments data.frame. Default is FALSE.
broken	if TRUE, the algorithm will simulate the extraction of logs only up to the defect_height. Default is FALSE.
defect_height	the height, in meters, from which the logs will be downgraded (if downgrade is TRUE) or log extraction simulation will be stopped (if broken is TRUE). Default is h * 0.5.
lang	language in which plot labels will be displayed. Current options are 'en' and 'pt-BR'. Default is 'en'.

Details

check the `bi_logs` function help for more details.

Value

a ggplot object.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)
```

```
bi <-  nlsLM(di ~ taper_bi(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6),
data=tree_scaling,
start=list(b0=1.8,b1=-0.2,b2=-0.04,b3=-0.9,b4=-0.0006,b5=0.07,b6=-.14))

coef_bi <- coef(bi)

dbh <- 25
h <- 20

assortments <- data.frame(
  NAME = c('15-25','4-15'),
  SED = c(15,4),
  MINLENGTH = c(2.65,2),
  MAXLENGTH = c(2.65,4.2),
  LOSS = c(5,5)
)

bi_logs_plot(dbh, h, coef_bi, assortments)
```

`bi_vol` *Estimate the total or partial volume of the tree, based on a fitted Bi (2000) taper function.*

Description

Estimates the total or partial volume of the tree from the diameter at breast height, total height, initial section height, final section height and coefficients of the Bi (2000) taper equation.

Usage

```
bi_vol(dbh, h, coef, hi, h0)
```

Arguments

`dbh`	tree diameter at breast height, in centimeters.
`h`	total tree height, in meters.
`coef`	numerical vector containing seven coefficients of the Bi taper equation.
`hi`	final height of the tree section whose volume will be calculated, in meters. Default is the total tree height (h).
`h0`	initial height of the tree section whose volume will be calculated, in meters. Default is 0 (ground height).

Details

the Bi (2000) variable-form taper function is represented mathematically by the following expression

di ~ dbh * (log(sin((pi/2) * (hi/h)))/(log(sin((pi/2) * (1.3/h)))))^(b0 + b1 * sin((pi/2) * (hi/h)) + b2 * cos((3 * pi/2) * (hi/h)) + b3 * (sin((pi/2) * (hi/h))/(hi/h)) + b4 * dbh + b5 * (hi/h) * dbh^0.5 + b6 * (hi/h) * h^0.5)

Value

a numeric value indicating the total or partial volume of the tree.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

bi <-  nlsLM(di ~ taper_bi(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6),
data=tree_scaling,
start=list(b0=1.8,b1=-0.2,b2=-0.04,b3=-0.9,b4=-0.0006,b5=0.07,b6=-.14))

coef_bi <- coef(bi)

dbh <- 25
h <- 20

bi_vol(dbh, h, coef_bi)

hi = 15
h0 = .2

bi_vol(dbh, h, coef_bi, hi, h0)
```

---

kozak_di

Estimate the diameter at a given height based on a fitted Kozak (2004) taper equation.

Description

Estimates the diameter at a given height of a tree from the diameter at breast height, total height and the coefficients of the Kozak (2004) taper function.

Usage

```
kozak_di(dbh, h, hi, coef, p)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
hi	height at which the diameter will be calculated, in meters.
coef	numerical vector containing nine coefficients of the Kozak taper function.
p	numerical value representing the first inflection point calculated in the segmented model of Max and Burkhart (1976).

Details

the Kozak (2004) variable-form taper function is represented mathematically by the following expression

di ~b0*(dbh^b1)*(h^b2)*((1-(hi/h)^(1/4))/(1-(p^(1/3))))^(b3*(hi/h)^4+b4*(1/exp(dbh/h))+b5*((1-(hi/h)^(1/4))/(1-(p^(1/3))))^0.1+b6*(1/dbh)+b7*(h^(1-(hi/h)^(1/3)))+b8*((1-(hi/h)^(1/4))/(1-(p^(1/3)))))

Value

a numeric value indicating the diameter at the given height.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

kozak <- nlsLM(di ~ taper_kozak(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6, b7, b8, p),
               start=list(b0=1.00,b1=.97,b2=.03,b3=.49,b4=-
                            0.87,b5=0.50,b6=3.88,b7=0.03,b8=-0.19, p = .1),
               data = tree_scaling,
               control = nls.lm.control(maxiter = 1000, maxfev = 2000)
)

coef_kozak <- coef(kozak)[-10]
p_kozak <- coef(kozak)[10]

h <- 20
dbh <- 25
di <- 5

kozak_di(dbh, h, di, coef_kozak, p_kozak)
```

kozak_hi *Estimate the height at which a given diameter occurs in a tree, based on a fitted Kozak (2004) taper equation.*

Description

Estimates the height at which a given diameter occurs in a tree, from the diameter at breast height, total height and coefficients of the Kozak (2004) taper function.

Usage

```
kozak_hi(dbh, h, di, coef, p)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
di	diameter whose height of occurrence will be estimated, in centimeters.
coef	numerical vector containing nine coefficients of the Kozak taper equation
p	numerical value representing the first inflection point calculated in the segmented model of Max and Burkhart (1976).

Details

the Kozak (2004) variable-form taper function is represented mathematically by the following expression

di ~b0*(dbh^b1)*(h^b2)*((1-(hi/h)^(1/4))/(1-(p^(1/3))))^(b3*(hi/h)^4+b4*(1/exp(dbh/h))+b5*((1-(hi/h)^(1/4))/(1-(p^(1/3))))^0.1+b6*(1/dbh)+b7*(h^(1-(hi/h)^(1/3)))+b8*((1-(hi/h)^(1/4))/(1-(p^(1/3)))))

Value

as numeric value indicating the height at which the given diameter occurs.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

kozak <- nlsLM(di ~ taper_kozak(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6, b7, b8, p),
               start=list(b0=1.00,b1=.97,b2=.03,b3=.49,b4=-
                            0.87,b5=0.50,b6=3.88,b7=0.03,b8=-0.19, p = .1),
               data = tree_scaling,
```

```
                control = nls.lm.control(maxiter = 1000, maxfev = 2000)
)

coef_kozak <- coef(kozak)[-10]
p_kozak <- coef(kozak)[10]

h <- 20
dbh <- 25
hi <- 15

kozak_hi(dbh, h, hi, coef_kozak, p_kozak)
```

`kozak_logs` *Simulate log extraction using a Kozak (2004) variable-form taper equation that describes the taper of the tree.*

Description

Simulate the extraction of logs from a tree from its measurements, taper function (Kozak (2004) variable-form taper equation), trunk quality characteristics and harvest parameters such as stump height and assortments.

Usage

```
kozak_logs(
  dbh,
  h,
  coef,
  p,
  assortments,
  stump_height,
  downgrade,
  broken,
  defect_height,
  eliminate,
  total_volume,
  only_vol
)
```

Arguments

`dbh`	tree diameter at breast height, in centimeters.
`h`	total tree height, in meters.
`coef`	numerical vector containing nine coefficients of the Kozak taper equation.
`p`	numerical value representing the first inflection point calculated in the segmented model of Max and Burkhart (1976).

assortments	a data.frame with five columns and n rows, where n is the number of different wood assortments to be obtained from the tree stem. The first column must contain the names of the assortments, the second, numerical, contains the minimum diameters at the small end of the logs, in centimeters. The third column, numerical, contains the minimum lengths of the logs, in meters. The fourth column, numerical, contains the maximum lengths of the logs, in meters. The fifth column, numerical, contains the values in centimeters referring to the loss of wood due to cutting logs. The algorithm prioritizes the extraction of assortments along the stem in the order presented in the data.frame, starting from the first line, to the last.
stump_height	tree cutting height, in meters. Default is 0.
downgrade	if TRUE, the algorithm,from the defect_height onwards, simulates log extraction only for the last assortment in the assortments data.frame. Default is FALSE.
broken	if TRUE, the algorithm will simulate the extraction of logs only up to the defect_height. Default is FALSE.
defect_height	the height, in meters, from which the logs will be downgraded (if downgrade is TRUE) or log extraction simulation will be stopped (if broken is TRUE). Default is 0 for downgrade = TRUE (the whole tree is downgraded) and h * 0.5 for broken = TRUE (the tree is broken from half its original/estimated total height).
eliminate	if TRUE, the algorithm does not get logs for any assortment present in the assortments table. All will be zero. Default is FALSE.
total_volume	if TRUE, it adds an additional column to the results data.frame with the estimate of the total volume of the tree, from the ground height to h if broken argument is FALSE, or to defect_height if broken is TRUE. Default is FALSE.
only_vol	if TRUE returns only volumes (does not return the number of logs). Default is FALSE.

Details

when the broken and downgrade arguments are set to TRUE, the defect_height value is considered as the break height of the tree, and the entire tree is downgraded.

Value

a list of two data.frames, the first (volumes) with the calculated volumes per assortment, and the second (logs) with the number of logs per assortment.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)
```

```
kozak <- nlsLM(di ~ taper_kozak(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6, b7, b8, p),
               start=list(b0=1.00,b1=.97,b2=.03,b3=.49,b4=-
                            0.87,b5=0.50,b6=3.88,b7=0.03,b8=-0.19, p = .1),
               data = tree_scaling,
               control = nls.lm.control(maxiter = 1000, maxfev = 2000)
)

coef_kozak <- coef(kozak)[-10]
p_kozak <- coef(kozak)[10]

h <- 20
dbh <- 25

assortments <- data.frame(
  NAME = c('15-25','4-15'),
  SED = c(15,4),
  MINLENGTH = c(2.65,2),
  MAXLENGTH = c(2.65,4.2),
  LOSS = c(5,5)
)

kozak_logs(dbh, h, coef_kozak, p_kozak, assortments)
```

`kozak_logs_plot` *Visualize the simulation of log cutting along the stem using a Kozak (2004) variable-form taper equation.*

Description

Plot the shape of the tree and visualize the extracted logs based on the tree measurements, assortments data.frame, and the Kozak (2004) variable-form taper equation.

Usage

```
kozak_logs_plot(
  dbh,
  h,
  coef,
  p,
  assortments,
  stump_height,
  downgrade,
  broken,
  defect_height,
  lang
)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
coef	numerical vector containing seven coefficients of the Kozak variable-form taper equation.
p	numerical value representing the first inflection point calculated in the segmented model of Max and Burkhart (1976).
assortments	a data.frame with five columns and n rows, where n is the number of different wood assortments to be obtained from the tree stem. The first column must contain the names of the assortments, the second, numerical, contains the minimum diameters at the small end of the logs, in centimeters. The third column, numerical, contains the minimum lengths of the logs, in meters. The fourth column, numerical, contains the maximum lengths of the logs, in meters. The fifth column, numerical, contains the values in centimeters referring to the loss of wood due to cutting logs. The algorithm prioritizes the extraction of assortments along the stem in the order presented in the data.frame, starting from the first line, to the last.
stump_height	tree cutting height, in meters. Default is 0.
downgrade	if TRUE, the algorithm,from the defect_height onwards, simulates log extraction only for the last assortment in the assortments data.frame. Default is FALSE.
broken	if TRUE, the algorithm will simulate the extraction of logs only up to the defect_height. Default is FALSE.
defect_height	the height, in meters, from which the logs will be downgraded (if downgrade is TRUE) or log extraction simulation will be stopped (if broken is TRUE). Default is h * 0.5.
lang	language in which plot labels will be displayed. Current options are 'en' and 'pt-BR'. Default is 'en'.

Details

check the kozak_logs function help for more details.

Value

a ggplot object.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

kozak <- nlsLM(di ~ taper_kozak(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6, b7, b8, p),
```

```
                start=list(b0=1.00,b1=.97,b2=.03,b3=.49,b4=-
                            0.87,b5=0.50,b6=3.88,b7=0.03,b8=-0.19, p = .1),
                data = tree_scaling,
                control = nls.lm.control(maxiter = 1000, maxfev = 2000)
)

coef_kozak <- coef(kozak)[-10]
p_kozak <- coef(kozak)[10]

h <- 20
dbh <- 25

assortments <- data.frame(
  NAME = c('15-25','4-15'),
  SED = c(15,4),
  MINLENGTH = c(2.65,2),
  MAXLENGTH = c(2.65,4.2),
  LOSS = c(5,5)
)

kozak_logs(dbh, h, coef_kozak, p_kozak, assortments)
```

---

kozak_vol *Estimate the total or partial volume of the tree, based on a fitted Kozak (2004) taper function.*

Description

Estimates the total or partial volume of the tree from the diameter at breast height, total height, initial section height, final section height and coefficients of the Kozak (2004) taper equation.

Usage

```
kozak_vol(dbh, h, coef, p, hi, h0)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
coef	numerical vector containing eight coefficients of the Kozak taper equation.
p	numerical value representing the first inflection point calculated in the segmented model of Max and Burkhart (1976).
hi	final height of the tree section whose volume will be calculated, in meters. Default is the total tree height (h).
h0	initial height of the tree section whose volume will be calculated, in meters. Default is 0 (ground height).

Details

the Kozak (2004) variable-form taper function is represented mathematically by the following expression

di ~ b0*(dbh^b1)*(h^b2)*((1-(hi/h)^(1/4))/(1-(p^(1/3))))^(b3*(hi/h)^4+b4*(1/exp(dbh/h))+b5*((1-(hi/h)^(1/4))/(1-(p^(1/3))))^0.1+b6*(1/dbh)+b7*(h^(1-(hi/h)^(1/3)))+b8*((1-(hi/h)^(1/4))/(1-(p^(1/3)))))

Value

a numeric value indicating the total or partial volume of the tree.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

kozak <- nlsLM(di ~ taper_kozak(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6, b7, b8, p),
               start=list(b0=1.00,b1=.97,b2=.03,b3=.49,b4=-
                            0.87,b5=0.50,b6=3.88,b7=0.03,b8=-0.19, p = .1),
               data = tree_scaling,
               control = nls.lm.control(maxiter = 1000, maxfev = 2000)
)

coef_kozak <- coef(kozak)[-10]
p_kozak <- coef(kozak)[10]

h <- 20
dbh <- 25
di <- 5

kozak_vol(dbh, h, coef_kozak, p_kozak)

hi = 15
h0 = .2

kozak_vol(dbh, h, coef_kozak, p_kozak, hi, h0)
```

`poly5_di` *Estimate the diameter at a given height based on a 5th degree polynomial function.*

Description

Estimates the diameter at a given height of a tree from the diameter at breast height, total height and the coefficients of the 5th degree polynomial function that describes the tree's taper.

Usage

```
poly5_di(dbh, h, hi, coef)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
hi	height at which the diameter will be calculated, in meters.
coef	numerical vector containing six coefficients of the 5th degree polynomial function that describes the tree's taper.

Value

a numeric value indicating the diameter at the given height.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

poli5 <- lm(did~hih+I(hih^2)+I(hih^3)+I(hih^4)+I(hih^5),tree_scaling)

coef_poli <- coef(poli5)

dbh <- 25
h <- 20
di <- 5

poly5_di(dbh, h, di, coef_poli)
```

---

poly5_hi

Estimate the height at which a given diameter occurs in a tree, based on a 5th degree polynomial function.

Description

Estimates the height at which a given diameter occurs in a tree, from the diameter at breast height, total height and coefficients of the 5th degree polynomial function that describes the tree's taper.

Usage

```
poly5_hi(dbh, h, di, coef)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
di	diameter whose height of occurrence will be estimated, in centimeters.
coef	numerical vector containing six coefficients of the 5th degree polynomial function that describes the tree's taper.

Value

as numeric value indicating the height at which the given diameter occurs.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

poli5 <- lm(did~hih+I(hih^2)+I(hih^3)+I(hih^4)+I(hih^5),tree_scaling)

coef_poli <- coef(poli5)

dbh <- 25
h <- 20
hi <- 15

poly5_hi(dbh, h, hi, coef_poli)
```

---

poly5_logs *Simulate log extraction using a 5th degree polynomial that describes the taper of the tree.*

Description

Simulate the extraction of logs from a tree from its measurements, taper function (5th degree polynomial), trunk quality characteristics and harvest parameters such as stump height and assortments.

Usage

```
poly5_logs(
  dbh,
  h,
  coef,
```

```
  assortments,
  stump_height,
  downgrade,
  broken,
  defect_height,
  eliminate,
  total_volume,
  only_vol
)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
coef	numerical vector containing six coefficients of the 5th degree polynomial function that describes the tree's taper.
assortments	a data.frame with five columns and n rows, where n is the number of different wood assortments to be obtained from the tree stem. The first column must contain the names of the assortments, the second, numerical, contains the minimum diameters at the small end of the logs, in centimeters. The third column, numerical, contains the minimum lengths of the logs, in meters. The fourth column, numerical, contains the maximum lengths of the logs, in meters. The fifth column, numerical, contains the values in centimeters referring to the loss of wood due to cutting logs. The algorithm prioritizes the extraction of assortments along the stem in the order presented in the data.frame, starting from the first line, to the last.
stump_height	tree cutting height, in meters. Default is 0.
downgrade	if TRUE, the algorithm,from the defect_height onwards, simulates log extraction only for the last assortment in the assortments data.frame. Default is FALSE.
broken	if TRUE, the algorithm will simulate the extraction of logs only up to the defect_height. Default is FALSE.
defect_height	the height, in meters, from which the logs will be downgraded (if downgrade is TRUE) or log extraction simulation will be stopped (if broken is TRUE). Default is 0 for downgrade = TRUE (the whole tree is downgraded) and h * 0.5 for broken = TRUE (the tree is broken from half its original/estimated total height).
eliminate	if TRUE, the algorithm does not get logs for any assortment present in the assortments table. All will be zero. Default is FALSE.
total_volume	if TRUE, it adds an additional column to the results data.frame with the estimate of the total volume of the tree, from the ground height to h if broken argument is FALSE, or to defect_height if broken is TRUE. Default is FALSE.
only_vol	if TRUE returns only volumes (does not return the number of logs). Default is FALSE.

Details

when the broken and downgrade arguments are set to TRUE, the defect_height value is considered as the break height of the tree, and the entire tree is downgraded.

Value

a list of two data.frames, the first (volumes) with the calculated volumes per assortment, and the second (logs) with the number of logs per assortment.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

poli5 <- lm(did~hih+I(hih^2)+I(hih^3)+I(hih^4)+I(hih^5),tree_scaling)

coef_poli <- coef(poli5)

dbh <- 25
h <- 20

assortments <- data.frame(
  NAME = c('15-25','4-15'),
  SED = c(15,4),
  MINLENGTH = c(2.65,2),
  MAXLENGTH = c(2.65,4.2),
  LOSS = c(5,5)
)

poly5_logs(dbh, h, coef_poli, assortments)
```

---

poly5_logs_plot *Visualize the simulation of log cutting along the stem using a 5th degree polynomial that describes the tree taper.*

Description

Plot the shape of the tree and visualize the extracted logs based on the tree measurements, assortments data.frame, and the 5th degree polynomial function that describes the tree's taper.

Usage

```
poly5_logs_plot(
  dbh,
  h,
  coef,
  assortments,
  stump_height,
  downgrade,
  broken,
  defect_height,
  lang
)
```

Arguments

dbh	tree diameter at breast height, in centimeters.
h	total tree height, in meters.
coef	numerical vector containing six coefficients of the 5th degree polynomial function that describes the tree's taper.
assortments	a data.frame with five columns and n rows, where n is the number of different wood assortments to be obtained from the tree stem. The first column must contain the names of the assortments, the second, numerical, contains the minimum diameters at the small end of the logs, in centimeters. The third column, numerical, contains the minimum lengths of the logs, in meters. The fourth column, numerical, contains the maximum lengths of the logs, in meters. The fifth column, numerical, contains the values in centimeters referring to the loss of wood due to cutting logs. The algorithm prioritizes the extraction of assortments along the stem in the order presented in the data.frame, starting from the first line, to the last.
stump_height	tree cutting height, in meters. Default is 0.
downgrade	if TRUE, the algorithm,from the defect_height onwards, simulates log extraction only for the last assortment in the assortments data.frame. Default is FALSE.
broken	if TRUE, the algorithm will simulate the extraction of logs only up to the defect_height. Default is FALSE.
defect_height	the height, in meters, from which the logs will be downgraded (if downgrade is TRUE) or log extraction simulation will be stopped (if broken is TRUE). Default is h * 0.5.
lang	language in which plot labels will be displayed. Current options are 'en' and 'pt-BR'. Default is 'en'.

Details

check the `poly5_logs` function help for more details.

Value

a ggplot object.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

poli5 <- lm(did~hih+I(hih^2)+I(hih^3)+I(hih^4)+I(hih^5),tree_scaling)

coef_poli <- coef(poli5)

dbh <- 25
h <- 20

assortments <- data.frame(
  NAME = c('15-25','4-15'),
  SED = c(15,4),
  MINLENGTH = c(2.65,2),
  MAXLENGTH = c(2.65,4.2),
  LOSS = c(5,5)
)

poly5_logs_plot(dbh, h, coef_poli, assortments)
```

`poly5_vol` *Estimate the total or partial volume of the tree, based on a 5th degree polynomial function that describes the taper of the tree.*

Description

Estimates the total or partial volume of the tree from the diameter at breast height, total height, initial section height, final section height and coefficients of the 5th degree polynomial function that describes the tree's taper.

Usage

```
poly5_vol(dbh, h, coef, hi, h0)
```

Arguments

`dbh`	tree diameter at breast height, in centimeters.
`h`	total tree height, in meters.
`coef`	numerical vector containing six coefficients of the 5th degree polynomial function that describes the tree's taper.

hi	final height of the tree section whose volume will be calculated, in meters. Default is the total tree height (h).
h0	initial height of the tree section whose volume will be calculated, in meters. Default is 0 (ground height).

Value

a numeric value indicating the total or partial volume of the tree.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

poli5 <- lm(did~hih+I(hih^2)+I(hih^3)+I(hih^4)+I(hih^5),tree_scaling)

coef_poli <- coef(poli5)

dbh <- 25
h <- 20

poly5_vol(dbh, h, coef_poli)

hi = 15
h0 = .2

poly5_vol(dbh, h, coef_poli, hi, h0)
```

---

select_and_remove *Remove unwanted data by selecting it*

Description

Delete unwanted records from the dataset (e.g. outliers) by selecting them in a scatter plot.

Usage

```
select_and_remove(data, xvar, yvar)
```

Arguments

data	a data.frame.
xvar	quoted name of the variable to be displayed in the x axis.
yvar	quoted name of the variable to be displayed in the y axis.

Value

the data.frame given to the `data` argument, without the selected points.

Examples

```
## Not run:
library(dplyr)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h) %>%
select_and_remove(., 'hih', 'did')

## End(Not run)
```

`taper_bi` *Bi (2004) Taper Function.*

Description

Bi (2004) Taper Function.

Usage

```
taper_bi(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6)
```

Arguments

`dbh`	tree diameter at breast height, in centimeters.
`h`	total tree height, in meters.
`hih`	ratio between the height of the section (hi) and the total height (h) .
`b0`, `b1`, `b2`, `b3`, `b4`, `b5`, `b6`	model parameters.

Value

a numeric value indicating the diameter at the section.

References

Bi, H. (2000). Trigonometric variable-form taper equations for Australian eucalypts. Forest Science, 46(3), 397-409.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

bi <-  nlsLM(di ~ taper_bi(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6),
data=tree_scaling,
start=list(b0=1.8,b1=-0.2,b2=-0.04,b3=-0.9,b4=-0.0006,b5=0.07,b6=-.14))
```

`taper_kozak` *Kozak (2004) Taper Function.*

Description

Kozak (2004) Taper Function.

Usage

```
taper_kozak(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6, b7, b8, p)
```

Arguments

`dbh`	tree diameter at breast height, in centimeters.
`h`	total tree height, in meters.
`hih`	ratio between the height of the section (hi) and the total height (h) .
`b0`, `b1`, `b2`, `b3`, `b4`, `b5`, `b6`, `b7`, `b8`	model parameters.
`p`	numerical value representing the first inflection point calculated in the segmented model of Max and Burkhart (1976).

Value

a numeric value indicating the diameter at the section.

References

Kozak, A. (2004). My last words on taper equations. The Forestry Chronicle, 80(4), 507-515.

Examples

```
library(dplyr)
library(minpack.lm)
library(timbeR)

tree_scaling <- tree_scaling %>%
mutate(did = di/dbh,
       hih = hi/h)

kozak <-  nlsLM(di ~ taper_kozak(dbh, h, hih, b0, b1, b2, b3, b4, b5, b6, b7, b8, p),
data=tree_scaling,
start=list(b0=1.00,b1=.97,b2=.03,b3=.49,b4=-0.87,b5=0.50,b6=3.88,b7=0.03,b8=-0.19,p =.1))
```

---

tree_scaling *Tree scaling example data*

Description

Diameter (cm) and height (m) measurements along the bole of 8 Pinus taeda trees.

Usage

```
data(tree_scaling)
```

Format

A data frame with 136 rows and 5 variables:

tree_id tree unique id

dbh diameter at breast height, in centimeters

h total tree height, in meters

hi tree section height, in meters

di diameter at the tree section, in centimeters

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