Package 'longleafGY'

May 31, 2018

Title Growth and yield simulator for Longlef pine (Pinus palustris)

Version 1.0.2

Description longleafGY is a systems of equations to predict and project growth and yield of Longleaf pine (Pinus palustris) stands with or without thinning using tree- or stand-level information.

Depends R (>= 3.3.3)

License GPL-2

Encoding UTF-8

LazyData true

RoxygenNote 6.0.1

R topics documented:

`module.BA` *Predicts and projects stand basal area based on stand-level information.*

Description

`module.BA` Predicts and projects stand basal area based on number of trees per hectare and dominant height at the stand-level using the equation: ln(BA) = c1 + c2 x ln(N) + c3 x ln(HDOM)

Usage

```
module.BA(N0 = NA, HDOM0 = NA, projection = FALSE, BA0 = NA, N1 = NA,
  HDOM1 = NA)
```

Arguments

`N0`	Numeric value of number of trees per hectare at age 0 (or initial age).
`HDOM0`	Numeric value of Dominant Height (m) at age 0.
`projection`	If TRUE then model projection from provided BA0 is executed for a 1 year increment. Default: FALSE.
`BA0`	Numeric value of Basal Area (m2/ha) at age 0 (required for model projection).
`N1`	Numeric value of number of trees per hectare at age 1 for projection.
`HDOM1`	Numeric value of Dominant Height (m) at age 1 for projection.

Value

A list containing:

- `BA0` Predicted Basal Area at age 0 (m2/ha).
- `BA1` Projected Basal Area at age 1 (m2/ha).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

References

Gonzalez-Benecke et al. (2012) Modeling Survival, Yield, Volume Partitioning and Their Response to Thinning for Longleaf Pine Plantations. Forests 3(4), 1104-1132; doi:10.3390/f3041104

Examples

```
# Example 1 - Predicting BA
module.BA(N0=1200, HDOM0=17.7)$BA0

# Example 2 - Projecting BA
module.BA(N0=1200, HDOM0=17.7, projection=TRUE, BA0=24, N1=1182, HDOM1=18.9)$BA1

# Example 3 - Varifying projection with prediction
sim.test <- module.input(TYPE='PLOT', BA0=17.63402, HDOM=14, AGE0=17, N0=1200, AGEF=28)
module.simulation(stand=sim.test)$sim.stand                  # All projections
module.BA(N0=1200, HDOM0=14, projection=FALSE)$BA0           # Prediction Age 17
```

```
module.BA(N0=1185.363, HDOM0=14.75542, projection=FALSE)$BA0  # Prediction Age 18
module.BA(N0=1019.661, HDOM0=21.26901, projection=FALSE)$BA0  # Prediction Age 28
```

`module.input` *Module of input tree- or stand-level data to prepare it for further simulations.*

Description

`module.input` Prepares tree- or stand-level data from a single plot, checks and completes missing values, and calculates several stand-level parameters including total volume. It also reads required information for further simulations including simulation age and details of future thinning. Some information is only traspassed to other modules. Note that form tree-level data individual tree (complete or incomplete) information is required.

Usage

```
module.input(TYPE = "PLOT", TREEDATA = NA, AREA = NA, SI = NA,
  HDOM0 = NA, AGE0 = NA, BA0 = NA, N0 = NA, AGEF = 50,
  THINNING = "FALSE", AGET = NA, BAR = NA, t = 5, d = 15,
  method = 2)
```

Arguments

`TYPE`	Character for type of input data. PLOT: stand-level data information, TREE: tree-level information. Default is PLOT
`TREEDATA`	Data frame with tree-level information with columns: PLOTID, TREEID, DBH, HT (these should be identical names).
`AREA`	Numeric value of size of the inventory plot (m2). Required for TYPE='TREE'.
`SI`	Numeric value of Site Index (m) (Dominant Height of the plot at age 50 years).
`HDOM0`	Numeric value of Dominant Height (m) at initial age (or age 0).
`AGE0`	Numeric value of initial stand age or age 0 (years).
`BA0`	Numeric value of Basal Area (m2/ha) at age 0 (required for model projection).
`N0`	Numeric value of number of trees per hectare at age 0.
`AGEF`	Numeric value of final stand age (in years) of simulation. Default is 50.
`THINNING`	If TRUE then a thinning is implemented according to AGET and BAR. Default is FALSE.
`AGET`	Numeric value of stand age (in years) where thinning is planned.
`BAR`	Numeric value of Relative Basal Area (%, 0-1) to be removed when thinning at age AGET.
`t`	Numeric value top stem diameter outside bark for merchantability limit (cm).
`d`	Numeric value of a DBH threshold limit for merchantable trees (cm).
`method`	Numeric value that identifies the method to estimate missing heights from TYPE='TREE'. 1: parametrized DBH-height model that requires DBH, BA and AGE, 2: fits a simple DBH-height model from available measurements using the equation: ln(Ht) = b0 + b1/DBH. Default method=2.

Value

A list containing the following:

- SI Site Index (m).
- AGE0 Initial stand age or age 0 (years).
- HDOM0 Dominant Height (m) at initial age (or age 0).
- BA0 Basal Area (m2/ha) at age 0.
- N0 Number of trees per hectare at age 0.
- QD Mean quadratic diameter (cm) at age 0.
- SDIR0 Relative stand density index (%) at age 0.
- VOL_OB0 Total stand-level volume outside bark (m3/ha) at age 0.
- VOL_IB0 Total stand-level volume inside bark (m3/ha) at age 0.
- VOLm_OB0 Merchantable stand-level volume outside bark (m3/ha) at age 0.
- VOLm_IB0 Merchantable stand-level volume inside bark (m3/ha) at age 0.
- AGEF Final stand age (in years) of simulation.
- THINNING Logical that indicates if thinning is implemented according to AGET and BAR.
- AGET Stand age (in years) where thinning is planned.
- BAR Relative Basal Area (%, 0-1) to be removed when thinning at age AGET.
- t Top stem diameter outside bark for merchantability limit (cm).
- d DBH threshold limit for merchantable trees (cm).
- method Selection of the method to estimate missing heights from TYPE='TREE'.

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

Examples

```
# Example 1 - Input stand-level data
module.input(TYPE='PLOT', BA0=17.3, SI=30, AGE0=17, N0=1200, AGEF=18)
module.input(TYPE='PLOT', BA0=17.3, HDOM0=16, AGE0=17, N0=1200, AGEF=18)
module.input(TYPE='PLOT', HDOM0=16, AGE0=17, N0=1200, AGEF=18)  # BA obtained by prediction

# Example 2 - Input with individual tree data
module.input(TYPE='TREE', TREEDATA=treedata, AREA=500, AGE0=23, AGEF=32)
```

---

module.N *Predicts the number of trees (mortality) at next age based on stand-level information.*

Description

module.N Estimates the number of trees (mortality) from initial age (AGE0) to next age (AGE1) based on stand level information based on the equation: N1 = N0 x exp((c1x(HDOM0/100)+c2xSDIR) x ((AGE1^c3)-(AGE0^c3)))

Usage

```
module.N(N0 = NA, HDOM0 = NA, SDIR0 = NA, AGE0 = NA, AGE1 = NA)
```

Arguments

N0	Numeric value of number of trees per hectare at age 0.
HDOM0	Numeric value of Dominant Height (m) at age 0.
SDIR0	Numeric value of Relative Stand Density Index for Longleaf (%) at age 0.
AGE0	Numeric value of intial stand age or age 0 (years).
AGE1	Numeric value of final stand age or age 1 for prediction (years).

Value

A value with the number of trees per hectare at age 1 (N1).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

References

Gonzalez-Benecke et al. (2012) - Modeling Survival, Yield, Volume Partitioning and Their Response to Thinning for Longleaf Pine Plantations. Forests, 3(4), 1104-1132; doi:10.3390/f3041104

Examples

```
module.N(N0=2500, HDOM0=14, SDIR0=45, AGE0=24, AGE1=25)$N1
```

---

module.simulation *Module that performs the simulations by projections at the desired age starting from initial conditions.*

Description

`module.simulation` Performs model projections of a stand to a final age based on information provided by the input module that contains: SI, AGE0, HDOM0, BA0, N0, QD0, SDIR0, VOL_0B0, VOL_IB0, VOLm_0B0, VOLm_IB0, AGEF, THINNING, AGET, BAR, t, d and method. Provides with a data frame with all relevant information for simulations from AGE0 to AGEF and thinning (if requested).

Usage

```
module.simulation(stand = NULL)
```

Arguments

stand	List with information originated from `module.input` containing: SI, AGE0, HDOM0, BA0, N0, QD0, SDIR0, VOL_0B0, VOL_IB0, VOLm_0B0, VOLm_IB0, AGEF, THINNING, AGET, BAR, t, d, method.

Value

A list containing a data frame (sim.stand) containing the columns below with simulations from AGE0 to AGEF and a logical value indicating if thinning was requested.

- AGE Stand age form simulations from AGE0 to AGEF (years).
- HDOM Dominant Height (m).
- SI Site Index (m).
- BA Basal Area (m2/ha).
- N Number of trees per hectare.
- QD Mean quadratic diameter (cm).
- SDIR Relative stand density index (%).
- VOL_OB Total stand-level volume outside bark (m3/ha).
- VOL_IB Total stand-level volume inside bark (m3/ha).
- VOLm_OB Merchantable stand-level volume outside bark (m3/ha).
- VOLm_IB Merchantable stand-level volume inside bark (m3/ha).
- CI Competition Index (required for THINNING=TRUE).
- BAU Basal Area (m2/ha) of unthinned counterpart (required for THINNING =TRUE).
- NU Number of trees per hectare of unthinned counterpart (required for THINNING=TRUE).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

References

Gonzalez-Benecke et al. (2012) - Modeling Survival, Yield, Volume Partitioning and Their Response to Thinning for Longleaf Pine Plantations. Forests, 3(4), 1104-1132; doi:10.3390/f3041104

See Also

module.input

Examples

```
# Example 1 - Input from plot-level data (not thinning)
sim1 <- module.input(TYPE='PLOT', BA0=17.3, SI=30, AGE0=17, N0=1200, AGEF=28, THINNING=FALSE)
module.simulation(stand=sim1)

# Example 2 - Input from tree-level data
sim2<-module.input(TYPE='TREE', TREEDATA=treedata, AREA=500, AGE0=23, AGEF=32)
module.simulation(stand=sim2)

# Example 3 - Input from plot-level data (with thinning)
sim3 <- module.input(TYPE='PLOT', BA0=17.3, SI=30, AGE0=17, N0=1200, AGEF=38,
                     THINNING=TRUE, AGET=22, BAR=0.25)
sims <- module.simulation(stand=sim3)$sim.stand
sims
plot(sims$AGE,sims$BAU,type="l",xlim=c(10,50),ylim=c(10,50),col=2,
     xlab='Age (years)', ylab='Basal Area (m2/ha)')
par(new=TRUE)
plot(sims$AGE,sims$BA,type="l",xlim=c(10,50),ylim=c(10,50),col=1,
```

```
     xlab='Age (years)', ylab='Basal Area (m2/ha)')
par(new=FALSE)
```

`module.VOL` *Calculates the total stand-level volume based on stand-level information.*

Description

`module.VOL` Calculates the total stand-level volume inside and outside bark for a plot based on the equation: ln(VOL) = d1 + d2xln(N) + d3xln(BA) + d4xln(BA/AGE) + d5xln(SI)

Usage

```
module.VOL(N = NA, BA = NA, AGE = NA, SI = NA)
```

Arguments

`N`	Numeric value of number of trees per hectare.
`BA`	Numeric value of Basal Area of the plot (m2/ha).
`AGE`	Numeric value of Age of the plot (in years).
`SI`	Numeric value of Site Index (m) (Dominant Height of the plot at age 50 years).

Value

A list containing the parameters:

- `VOL_OB` Total stand-level volume outside bark (m3/ha).
- `VOL_IB` Total stand-level volume inside bark (m3/ha).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

References

Gonzalez-Benecke et al. (2012) - Modeling Survival, Yield, Volume Partitioning and Their Response to Thinning for Longleaf Pine Plantations. Forests, 3(4), 1104-1132; doi:10.3390/f3041104

Examples

```
module.VOL(N=2500, BA=30, AGE=25, SI=15)
```

`module.VOLm` *Calculates the stand-level merchantable volume based on stand-level information.*

Description

`module.VOLm` Calculates the stand-level merchantable volume inside and outside bark fro a plot based on the equation: VOLm = VOL x exp(m1 x ((t/QD)^m2) + m3 x (N^m4) x (d/QD)^m5)

Usage

```
module.VOLm(N = NA, QD = NA, t = NA, d = NA, VOL_OB = NA,
  VOL_IB = NA)
```

Arguments

`N`	Numeric value of number of trees per hectare.
`QD`	Numeric value of mean Quadratic Diameter (cm).
`t`	Numeric value top stem diameter outside bark for merchantability limit (cm).
`d`	Numeric value of a DBH threshold limit for merchantable trees (cm).
`VOL_OB`	Total stand-level volume outside bark (m3/ha).
`VOL_IB`	Total stand-level volume inside bark (m3/ha).

Value

A list containing the parameters:

- `VOLm_OB` Merchantable stand-level volume outside bark (m3/ha).
- `VOLm_IB` Merchantable stand-level volume inside bark (m3/ha).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

References

Gonzalez-Benecke et al. (2012) - Modeling Survival, Yield, Volume Partitioning and Their Response to Thinning for Longleaf Pine Plantations. Forests, 3(4), 1104-1132; doi:10.3390/f3041104

See Also

`module.VOL`

Examples

```
VOL_OB<-module.VOL(N=2500, BA=30, AGE=25, SI=15)$VOL_OB
VOL_IB<-module.VOL(N=2500, BA=30, AGE=25, SI=15)$VOL_IB
QD<-stand.STAND(BA=30, N=2500)$QD
module.VOLm(N=2500, QD=QD, t=3, d=5, VOL_OB=VOL_OB, VOL_IB=VOL_IB)
```

prepare.tree *Checks and prepares tree-level data from a single plot and calculates some stand-level parameters.*

Description

prepare.tree Checks and prepares tree-level data from a single plot and then calculates stand-level parameters such as basal area, number of trees per hectarea and dominant height. The provided vector of total heights can have missing information. If there are missing trees, there are two methods to use: 1) Estimates heights according to a parametrized DBH-height model, or 2) Estimates heights by fitting a simple DBH-height model that requires at least 10 measurements. Missing values are indentified as 'NA'.

Usage

```
prepare.tree(TREEID = NA, DBH = NA, HT = NA, AREA = NA, AGE = NA,
  method = 2)
```

Arguments

TREEID	Vector of unique tree identification.
DBH	Vector of diameter at breast height (DBH, cm). Must be complete and have the same size and order as TREEID.
HT	Vector of total height (m). Must be of the same size and order as TREEID.
AREA	Numeric value of area of the inventory plot (m2).
AGE	Numeric value of stand age (years). Required if method = 1.
method	Numeric value that identifies the method to estimate missing heights. 1: parametrized DBH-height model, 2: fits a simple DBH-height model from available measurements. Default method = 2.

Value

A list containing the following:

- BA Basal Area (m2/ha).

- N Number of trees per hectarea.

- HDOM Dominant Height (m).

- tree.table Data frame with all tree data an observed heights (for the ones provided) and estimated heights (for those missing). The data frame contains the columns: TREEID, DBH and HT.

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

See Also

tree.HT

Examples

```
# Example - Stand-level information from inventory data
TREEID <- treedata$TREEID
DBH <- treedata$DBH
HT <- treedata$HT
prepare.tree(TREEID=TREEID, DBH=DBH, HT=HT, AREA=500, AGE=22, method=2)
```

`stand.SDI` *Calculates relative stand density index for Longleaf Pine (*Pinus palustris*)*

Description

`stand.SDI` Calculates the relative stand density index (RSDI, %) for Longleaf in a single plot using the expression: RSDI = 100xNx(QD/25.4)^1.605/SDImax. For Longleaf pine (*Pinus palustris*) SDImax is 1200 trees/ha. At least two parameters are required to complete the missing.

Usage

```
stand.SDI(N = NA, QD = NA)
```

Arguments

`N`	Numeric value of the number of trees per hectare.
`QD`	Numeric value of mean quadratic diameter (cm).

Value

A value for the relative stand density index (RSDI, %).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

Examples

```
stand.SDI(QD=18, N=1660)
```

`stand.SITE` *Calculates dominant height, site index and stand age for a plot.*

Description

`stand.SITE` Calculates dominant height, site index (at reference age 50 year) or stand age for a plot based on the equation following dominant height equation: HDOM = SI x ((1-exp(a1 x Age)) / (1-exp(a1 x 50)))^a2 The definition of HDOM is based on the top 25th percentile of the tree heights. At least two parameters are required to calculate the thrid missing parameter.

Usage

```
stand.SITE(HDOM = NA, SI = NA, AGE = NA)
```

Arguments

HDOM	Numeric value of mean Dominant Height (m).
SI	Numeric value of Site Index (m) (Dominant Height of the plot at age 50 years).
AGE	Numeric value of stand Age (years).

Value

A list containing the parameters:

- HDOM Dominant Height (m).
- SI Site Index (m).
- AGE Age (years).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

References

Gonzalez-Benecke et al. (2012) - Modeling Survival, Yield, Volume Partitioning and Their Response to Thinning for Longleaf Pine Plantations. Forests, 3(4), 1104-1132; doi:10.3390/f3041104

Examples

```
stand.SITE(SI=30,AGE=40)$HDOM     # Missing HDOM
stand.SITE(HDOM=27.5,AGE=40)$SI   # Missing SI
stand.SITE(HDOM=27.5,SI=33.3)$AGE # Missing AGE
```

---

stand.STAND — *Calculates the mean quadratic diameter, basal area or number of trees.*

Description

stand.STAND Calculates the mean quadratic diameter, basal area or number of trees based on stand-level information of the plot. At least two parameters are required to calculate the third missing parameter.

Usage

```
stand.STAND(BA = NA, N = NA, QD = NA)
```

Arguments

BA	Numeric value of basal area of the plot (m2/ha).
N	Numeric value of number of trees per hectare.
QD	Numeric value of mean quadratic diameter (cm).

Value

A list containing the parameters:

- BA Basal Area (m2/ha).
- N Number of trees per hectare.
- QD Mean Quadratic Diameter (cm).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

Examples

```
stand.STAND(QD=18, N=1660)$BA   # Missing BA
stand.STAND(BA=42, QD=18)$N     # Missing N
stand.STAND(BA=42, N=1660)$QD   # Missing QD
```

---

tree.HDOM *Calculate dominant height for a plot based on tree-level data.*

Description

tree.HDOM Calculate the dominant height for a plot based on tree-level data based on the top 25th percentile of the tree heights. The provided vector of heights should be complete without missing data.

Usage

```
tree.HDOM(HT = NA)
```

Arguments

HT	Vector of tree heights (m) for a given plot (must be complete).

Value

A value with Dominant Height (HDOM, m) for the plot.

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

Examples

```
HT <- tree.HT(DBH=treedata$DBH, HT=treedata$HT, method=2)$HTFIN
tree.HDOM(HT=HT)
```

tree.HDOM.m *Calculate dominant height for a plot based on tree-level data.*

Description

tree.HDOM.m Calculate the dominant height for a plot based on tree-level data based on the top 25th percentile of the tree heights. The provided vector of heights should be complete without missing data.

Usage

```
tree.HDOM.m(HT = NA, DBH = NA, AREA = NA)
```

Arguments

HT	Vector of tree heights (m) for a given plot (must be complete).
DBH	Vector of diameter at breast height (DBH, cm). Must be complete and have the same size and order of HT.
AREA	Numeric value of area of the inventory plot (m2).

Value

A value with Dominant Height (HDOM, m) for the plot.

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

Examples

```
HT <- tree.HT(DBH=treedata$DBH, HT=treedata$HT, method=2)$HTFIN
DBH <- treedata$DBH
AREA <- 301
tree.HDOM.m(HT=HT, DBH=DBH, AREA=AREA)
```

tree.HT *Estimates the total height of trees for a single plot.*

Description

tree.HT Estimates the total height of trees that have missing height from tree-level data. For the missing trees there are two methods to use: 1) Estimates heights according to a parametrized DBH-height model, or 2) Estimates heights by fitting a simple DBH-height model that requires at least 10 measurements. Missing values are indentified as 'NA'.

Usage

```
tree.HT(DBH, HT, AREA = NA, AGE = NA, BA = NA, method = 2)
```

Arguments

DBH	Vector of diameter at breast height (DBH, cm). Must be complete and have the same size and order as TREEID.
HT	Vector of total height (m). Must be of the same size and order as TREEID.
AREA	Numeric value of area of the inventory plot (m2).
AGE	Numeric value of stand age (years). Required if method = 1.
BA	Numeric value of Basal Area (m2/ha). Required if method = 1.
method	Numeric value that identifies the method to estimate missing heights. 1: parametrized DBH-height model that requires DBH, BA and AGE, 2: fits a simple DBH-height model from available measurements using the equation: ln(HT) = b0 + b1/DBH. Default method = 2.

Value

A list containing the following:

- HTFIN A vector of final tree heigths (m), replacing the missing values for estimated heigths and retaining the observed heights.
- r2 A value with the coefficient of determination from the fitting the DBH-height model when method = 2.

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

References

Gonzalez-Benecke et al. (2013) - Individual Tree Diameter, Height, and Volume Functions for Longleaf Pine. Forest Science 60(1):43-56; doi:10.5849/forsci.12-074

See Also

tree.STAND

Examples

```
# Example 1 - Method 1 - Parametrized DBH-height model
DBH <- c(9.3,11.1,15.5,9,14.8,27.3,11.4,6.6,12.6,17.5,6.3,7.2,11.5,13.6,7.3,12,11.9,8.1,7.6,5)
HT <- c(11.8,12.3,NA,NA,15.3,18,12,NA,14.5,NA,NA,NA,NA,NA,10.3,14.6,NA,NA,NA,NA)
tree.HT(DBH=DBH, HT=HT, AREA=200, AGE=47, method=1)

# Example 2 - Method 2 - Simple DBH-height model
DBH <- treedata$DBH
HT <- treedata$HT
tree.HT(DBH=DBH, HT=HT, method=2)
```

tree.STAND — *Calculates the basal area, number of trees and mean quadratic diameter for a plot based on tree-level data.*

Description

tree.STAND Calculates the basal area, number of trees and mean quadratic diameter for a plot based on tree-level data.

Usage

```
tree.STAND(DBH, AREA)
```

Arguments

DBH	Vector of diameter at breast height (DBH, cm). Must be complete
AREA	Numeric value of the size of the plot (m2).

Value

A list containing the parameters:

- BA Basal Area (m2/ha).
- N Number of trees per hectare.
- QD Mean Quadratic Diameter (cm).

Author(s)

Priscila Someda-Dias, Salvador A. Gezan

Examples

```
# Example - Stand information from inventory data
DBH <- treedata$DBH[!is.na(treedata$DBH)]
tree.STAND(DBH=DBH, AREA=301)
```

treedata — *Data from inventory at tree-level to test*

Description

A dataset containing the measurements at tree-level of 60 trees in the same plot. The age of meadurement is 5 years and plot area is 301 square meters.

Usage

```
treedata
```

Format

A data frame with 60 observations and 5 variables:

- `PLOTID` Unique plot identification. For a single plot, all trees should have the same PLOTID.
- `TREEID` Unique tree identification. Must be complete.
- `DBH` Diameter at breast height (DBH, cm). Must ve the same size and order as TREEID.
- `HT` Total height (m). Must be of the same size and order as TREEID.
- `OBS` Aditional information about the tree.

Source

http://www.sfrc.ufl.edu/CFGRP/

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