

Package ‘taperNOR’

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Type Package

Title Taper, Volume and Bark Thickness Models for Spruce, Pine and Birch in Norway

Version 0.2.1

Description Stem taper, bark thickness, and volume models for the main Norwegian tree species (Norway spruce, Scots pine, and birch), based on Hansen et al. (2023) <[doi:10.1080/02827581.2023.2243821](https://doi.org/10.1080/02827581.2023.2243821)> and the correction <[doi:10.1080/02827581.2024.2358467](https://doi.org/10.1080/02827581.2024.2358467)>. Provides functions to predict stem diameter along the bole, bark thickness, and stem volume by numerical integration of the taper curve, and to invert these relationships (e.g. estimating height and diameter at breast height from measured diameters).

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URL <https://github.com/SmartForest-no/taperNOR>

BugReports <https://github.com/SmartForest-no/taperNOR/issues>

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Contents

barkNOR	2
dlocation	3
hfromd	4
kublin_nor	4
plot_taper	5
taperNOR	6
volume	7
Index	9

barkNOR	<i>Bark model for spruce, pine, and birch for Norway</i>
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Description

The bark models are based on Hannrup B. 2004. Funktioner för skattning av barkens tjocklek hos tall och gran vid avverkning med skördare. (Functions for prediction of bark thickness of Norway spruce and Scots pine at CTL-harvesting). Arbetsrapport 575. Skogforsk, Uppsala. via Stängle et al. 2017. Comparison of models for estimating bark thickness of *Picea abies* in southwest Germany: the role of tree, stand, and environmental factors. *Ann For Sci.* 74(1):16.

Usage

```
barkNOR(d, h, dbh, h_top, sp = "spruce")
```

Arguments

d	diameter (cm).
h	height above ground (m).
dbh	diameter at breast height, 1.3 m above ground (cm).
h_top	tree height above ground (m).
sp	species ('spruce', 'pine' or 'birch'; 1:3)

Value

double bark thickness (cm) at height h with diameter d.

Examples

```
barkNOR(d=30, h=1, dbh=25, h_top=30, sp="pine")

taper<-taperNOR(h=(0:300)/10, dbh=25, h_top=30, sp="pine")
bark<-barkNOR(d=taper, h=(0:300)/10, dbh=25, h_top=30, sp="pine")
plot((0:300)/10, taper, type="l", col="brown", xlab="height (m)", ylab="taper/bark (cm)")
points((0:300)/10, taper-bark/10, type="l", col="green")
legend("topright", legend = c("taper", "bark"), fill=c("brown", "green"), border=NA)
```

```
points((0:300)/10,bark,type="l",ylab="bark (cm)",xlab="height (m)")
```

dlocation	<i>Estimate height of diameters along the stem</i>
-----------	--

Description

Estimates heights of given diameters along the stem using optimization of the taper function.

Usage

```
dlocation(dbh, h_top, d, sp = "spruce", with_bark = TRUE)
```

Arguments

dbh	diameter at breast height (1.3 m above ground) over bark (cm).
h_top	height above ground of diameter measurements (m).
d	diameters (cm).
sp	species.
with_bark	diameter with (TRUE, default) or without bark (FALSE).

Value

Height of given diameter (m).

Examples

```
dlocation(dbh=35,h_top=35,d=c(25,40,12,2,70),sp="birch")
dlocation(dbh=35,h_top=35,d=c(25,40,12,2,70),sp="birch",with_bark=FALSE)

D<-35
H<-34
Sp<-"G"

#Case 1:
dia<-21
h_vol<-dlocation(d=dia,dbh=D,h_top=H,sp=Sp)
volume(D,H,sp=Sp,h_vol_lower = h_vol)

#Case2:
dia<- c(21,16)
A<-1.2
h_vol<- dlocation(d=dia,dbh=D,h_top=H,sp=Sp)
if (diff(h_vol)>A) volume(D,H,sp=Sp,h_vol_lower = h_vol[1],h_vol_upper=h_vol[2])
```

hfromd	<i>Estimate tree height above ground from diameters</i>
--------	---

Description

Estimates tree height above ground from diameters using optimization of the taper function.

Usage

```
hfromd(d, h, sp = "spruce", output = "h", grd_search = FALSE)
```

Arguments

d	diameters (cm).
h	height above ground of diameter measurements (m).
sp	species
output	output from optimization: 'h' outputs the tree height, 'd' diameter at breast height, 'all' result of optim.
grd_search	if TRUE optimization is run on a matrix of initial parameters. The result of the best fit is returned. Might give better result at cost of performance.

Value

Tree height above ground (m).

Examples

```
hfromd(d=c(39,27),h=c(2,7),sp="birch")
```

kublin_nor	<i>Taper model for spruce, pine, and birch for Norway with dynamic diameter input</i>
------------	---

Description

Based on Kublin et al. 2013. A flexible stem taper and volume prediction method based on mixed-effects B-spline regression. *Eur J For Res.* 132(5-6):983–997 and code in Kublin & Breidenbach (<https://CRAN.R-project.org/package=TapeR>).

Usage

```
kublin_nor(Hx = NULL, Hm, Dm, mHt, sp = 1, Dx = NULL, ...)
```

Arguments

Hx	height above ground where to return diameters (m)
Hm	height above ground of measured diameters (m)
Dm	measured diameters (cm)
mHt	measured tree height (m) above ground
sp	species. Spruce and pine are currently supported (spruce: "spruce", "s", "gran", "g", "1"; pine: "pine", "p", "furu", "f", "2"). The Kublin (TapeR) mixed-effects model has not yet been fitted for birch in this package, so birch raises an error - use taperNOR for birch, or supply a fitted par.lme.
Dx	or diameters (cm) for which to return a height
...	parameters handed over to E_DHx_HmDm_HT.f or E_HDx_HmDm_HT.f

Details

Allows the use of multiple diameters measured at various points along the stem to estimate taper.

Value

When Hx is given: diameters at Hx (cm). When Dx is given: heights where d=Dx (m). TapeR: :E_HDx_HmDm_HT.f() only root-finds a single height per call, so when Dx has length > 1 it is called once per element of Dx and the resulting heights are combined into a vector of the same length as Dx.

Examples

```
# Spruce stem with diameters of 30 cm at 1.3 m and 22 cm at 5 m above
# ground, and a total height of 25 m. (Spruce and pine are supported.)

# Height(s) (m) at which the stem reaches 25 and 15 cm in diameter:
kublin_nor(Dx = c(25, 15), Hm = c(1.3, 5), Dm = c(30, 22), mHt = 25, sp = "spruce")

# Diameters (cm) predicted at 1.3, 5 and 10 m above ground (pine):
kublin_nor(Hx = c(1.3, 5, 10), Hm = c(1.3, 5), Dm = c(30, 22), mHt = 25, sp = "pine")$DHx
```

plot_taper

Plot taper curve

Description

Plots the taper curve

Usage

```
plot_taper(dbh, h_top, sp = "spruce", with_bark = TRUE)
```

Arguments

dbh	diameter at breast height, 1.3 m above ground (cm).
h_top	tree height above ground (m).
sp	species
with_bark	plot taper curve with (TRUE, default) or without bark (FALSE).

Value

No return value. Called for its side effect of drawing a taper-curve plot on the current graphics device.

Examples

```
#one tree
plot_taper(33,30)

# multiple trees
plot_taper(dbh=c(33,20,18),h_top=c(30,25,20),sp=c(1,1,3))

# different tree species with same dbh and height
plot_taper(dbh=rep(25,3),h_top=rep(27,3),sp=1:3)

#one tree with and without bark
plot_taper(dbh=rep(25,2),h_top=rep(27,2),sp=1,with_bark=c(TRUE,FALSE))
```

taperNOR

Taper model for spruce, pine, and birch in Norway

Description

Computes stem diameters (taper) along the bole of spruce, pine, and birch in Norway. The function implements the taper equations described in Hansen et al. (2023), based on Kozak's (1988) variable-exponent taper equation. The original article by Hansen et al. (2023) contains minor errata (e.g., missing brackets, the use of 'Log' instead of 'ln', and a sign error at 'b7' in the pine taper model), but these do not affect the present implementation.

Usage

```
taperNOR(h, dbh, h_top, sp = "spruce", with_bark = TRUE)
```

Arguments

h	A numeric vector of heights above ground (in meters) at which to return diameters.
dbh	Diameter at breast height (1.3 m above ground), over bark (in centimeters).
h_top	Total tree height (in meters).

sp	<p>Character or numeric value indicating the species; recognized inputs include:</p> <ul style="list-style-type: none"> • spruce: "spruce", "s", "gran", "g", "1" • pine: "pine", "p", "furu", "f", "2" • birch: "birch", "b", "bjørk", "bjork", "bj", "lauv", "l", "3" <p>Defaults to "spruce".</p>
with_bark	<p>Logical. If TRUE (the default), returns diameter over bark. If FALSE, diameter under bark is computed by subtracting bark thickness via barkNOR.</p>

Value

A numeric vector of diameters (in centimeters) at each height in h.

References

Hansen, E., Rahlf, J., Astrup, R., & Gobakken, T. (2023). Taper, volume, and bark thickness models for spruce, pine, and birch in Norway. *Scandinavian Journal of Forest Research*, doi:10.1080/02827581.2023.2243821.

Kozak, A. (1988). A variable-exponent taper equation. *Canadian Journal of Forest Research*, 18(11), 1363–1368.

See Also

[barkNOR](#) for details on bark thickness subtraction.

Examples

```
# Example usage:
# Calculate taper for pine, at heights 1:30 m, dbh = 20 cm, total height = 30 m:
taperNOR(h = 1:30, dbh = 20, h_top = 30, sp = "pine", with_bark = TRUE)

# To get diameters under bark:
taperNOR(h = 1:30, dbh = 20, h_top = 30, sp = "pine", with_bark = FALSE)
```

volume

Calculate volume

Description

Calculates volume from taper model by integrating the taper function.

Usage

```
volume(  
  dbh,  
  h_top,  
  h_vol_lower = NA,  
  h_vol_upper = NA,  
  sp = "spruce",  
  with_bark = TRUE  
)
```

Arguments

dbh	numeric vector of diameters at breast height, 1.3 m above ground (cm).
h_top	numeric vector of tree heights above ground (m).
h_vol_lower	numeric vector of lower height for stem volume calculation (m). NA in h_vol_lower is replaced by stump height (1% of h_top).
h_vol_upper	numeric vector of upper height for stem volume calculation (m). NA in h_vol_upper is replaced by h_top.
sp	species.
with_bark	calculate volume over (TRUE, default) or under bark (FALSE).

Value

Timber volume (m³).

Examples

```
volume(20, 30)  
volume(dbh=c(20,25,30), h_top=c(30,25,37))  
volume(dbh=rep(25,11), h_top=rep(30,11),h_vol_lower=seq(0,30,3))  
volume(dbh=rep(25,11), h_top=rep(30,11),h_vol_upper=seq(0,30,3))  
volume(dbh=rep(25,11), h_top=rep(30,11),h_vol_lower=0,h_vol_upper=seq(0,30,3),with_bark=FALSE)
```

Index

barkNOR, [2](#), [7](#)

dlocation, [3](#)

hfromd, [4](#)

kublin_nor, [4](#)

plot_taper, [5](#)

taperNOR, [5](#), [6](#)

volume, [7](#)