Master’s Thesis

Notes

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Contents

1 Function by Nagel 1999

1.1 Original form

Source: email by Matthias Schmidt from 2017-04-27 12:06:00.

$$h_{100}(100) = \frac{h_{100}(x) + 49.872 - 7.3309 \cdot \ln(x) - 0.77338 \cdot \ln(x)^2}{0.52684 + 0.10542 \cdot \ln(x)}, \tag{1}$$

where $h_{100}(x)$ is the value of h_{100} at age x.

1.2 Solved for $h_{100}(x)$

$$\begin{aligned} h_{100}(x) =& h_{100}(100) \cdot (0.52684 + 0.10542 \cdot \ln(x)) \\ & - 49.872 + 7.3309 \cdot \ln(x) + 0.77338 \cdot \ln(x)^2 \end{aligned} \tag{2}$$

2 Explanation of Data Frame Columns

Date: November 9, 2017

2.1 SI.h100

Introduced with: gmax_1.5.RData

Relevant R Code:

```
SI.h100 <- (h100 + 49.87200 - 7.33090 * log(x = alt)
           - 0.77338 * ((log(x = alt))^2.0))
           / (0.52684 + 0.10542 * log(x = alt))
```

Explanation: "SI.h100" holds the absolute stand index for a given stand (i.e., the value of h_{100} at age 100 a) calculated with the function by Nagel (see email by Matthias Schmidt from 2017-04-27 12:06).

2.2 h100.EKL.I

Introduced with: gmax_1.6.RData

Relevant R Code:

```
SI.h100.EKL.I <- 32.4 ## for beech
SI.h100.EKL.I <- 35.1 ## for spruce
h100.EKL.I <- SI.h100.EKL.I * (0.52684 + 0.10542
              * log(x = alt)) - 49.872 + 7.3309
              * log(x = alt) + 0.77338 * (log(x = alt))^2
```

Explanation: "h100.EKL.I" holds h_{100} for a given age if the stand were EKL I.

2.3 h100.diff.EKL.I

Introduced with: gmax_2.0.RData

Relevant R Code:

```
h100.diff.EKL.I <- h100 - h100.EKL.I
```

2.4 *SI.h100.diff.EKL.I*

Introduced with: gmax_4.4.RData

Relevant R Code:

```
SI.h100.EKL.I <- 32.4 ## for beech
SI.h100.EKL.I <- 35.1 ## for spruce
SI.h100.diff.EKL.I <- SI.h100 - SI.h100.EKL.I
```

3 Explanation of Data Frames

These explanations are valid as of commit 9563c6f69b2e4103810532bc162e5fd0a7f91b6b.

3.1 bart.SPECIES.clean.1.0

- Base data frame: `bart.SPECIES`
- Lines excluded individually:
  - Beech: `art != 211`
  - Spruce: `art != 511`
  - `ksha.rel < 0.7`
- Lines excluded consecutively:
  - `gha.rel.cha < 0`

3.2 bart.SPECIES.clean.1.1

- Base data frame: `bart.SPECIES.clean.1.0`
- Lines excluded consecutively:
  - `ghaa > 0.20 * gha`

3.3 bart.SPECIES.clean.1.2

- Base data frame: `bart.SPECIES.clean.1.0`
- Lines excluded consecutively:
  - `ghaa > 0.15 * gha`

3.4 bart.SPECIES.clean.1.3

- Base data frame: `bart.SPECIES.clean.1.0`
- Lines excluded consecutively:
  - `ghaa > 0.10 * gha`

3.5 *bart.SPECIES.clean.1.4*

- Base data frame: `bart.SPECIES.clean.1.0`
- Lines excluded consecutively:
  - `ghaa > 0.05 * gha`

3.6 *bart.SPECIES.clean.1.5*

- Base data frame: `bart.SPECIES.clean.1.0`
- Lines excluded consecutively:
  - `ghaa > 0.00 * gha`

3.7 *bart.SPECIES.clean.1.5*

- Base data frame: `bart.SPECIES.clean.1.0`
- evdids excluded:
  - `nrow(EDVID.subset) == 1`
- Lines excluded individually per `edvid`:
  - First line:
    ```
    (log.nha[i + 1] - log.nha[i]) /
    (log.dg[i + 1] - log.dg[i]) > SPECIES.upper.threshold
    ```
  - Intermediate lines:
    ```
    (log.nha[i] - log.nha[i - 1]) /
    (log.dg[i] - log.dg[i - 1]) < SPECIES.lower.threshold &&
    (log.nha[i + 1] - log.nha[i]) /
    (log.dg[i + 1] - log.dg[i]) > SPECIES.upper.threshold
    ```
  - Last line:
    ```
    (log.nha[i] - log.nha[i - 1]) /
    (log.dg[i] - log.dg[i - 1]) < SPECIES.lower.threshold
    ```

Table 1: Upper and lower thresholds of the log(N) log(dg)-slope per species.

Species	Upper threshold	Lower threshold
Beech	-1.00	-1.94
Spruce	-1.00	-1.88

Species	Upper threshold	Lower threshold

4 Special remarks per edvid

Table 2: Contents of parz$edvid and parz$BESONDERHEITEN. Information on strength of thinning highlighted. Note: "strength of thinning" and "thinning intensity" are NOT the same (cp. Assmann (1961), p. 213 fn. 1).

parz$edvid	parz$BESONDERHEITEN
05451102	
06451102	2000 intern aufgegeben
07151102	aufgeg. m. Schreiben v. 21.10.2009;1990 Kalkung
07551103	1986 Kalkung; 2001 aufgegeben
07551105	1977 aufgegeben: keine ertragskundl. Aufnahme
07551107	1986 Kalkung; 2012 aufgegeben
11651100	
4665111A	1977 Vollumbruch. unbehandelt. Erhebung Aststärkendurchmesser
4665112B	1977 Vollumbruch. Auszeichnung nach Baumzahlleitkurve. Erhebung Aststärkendurchmesser
4665113B	1977 Vollumbruch. Auszeichnung nach Baumzahlleitkurve. Erhebung Aststärkendurchmesser
4665114B	1977 Vollumbruch. Auszeichnung nach Baumzahlleitkurve. Erhebung Aststärkendurchmesser
4675111A	unbehandelt. Erhebung Aststärkendurchmesser
4675112A	unbehandelt. Erhebung Aststärkendurchmesser
4675113A	unbehandelt. Erhebung Aststärkendurchmesser
4675113B	ab 2009 st. NDF wegen WW (Kyrill)
4675114A	unbehandelt. Erhebung Aststärkendurchmesser
47451104	Standort 09.3.2.4. z.T. 14.3.2.4. Df. nach Baumzahlleitkurve
55751102	gegattert
56151100	Standort 80% 9.2.2.2. 20% 15.2.2.2
61851101	keine Durchforstung. da NP (Schutzzone 1). Düngungsangaben nachtragen !!!
61851102	keine Durchforstung. da NP (Schutzzone 1); ungedüngt
87021515	Prov.: Buche
87021516	Prov.: Buche
87021517	Prov.: Buche
87021520	Prov.: Buche
87021521	Prov.: Buche
87021522	Prov.: Buche

parz$edvid	parz$BESONDERHEITEN
A6251101	Feinkartierung; Kompensationskalkung (3 t/ha)
A6251104	Feinkartierung; Kompensationskalkung (3 t/ha)
J5851106	Nullfläche
J6351111	Df.art: starke Niederdurchforstung u. BZL
J6351121	Df.art: starke Niederdurchforstung u. BZL
J6351131	Df.art: starke Niederdurchforstung u. BZL
J6351141	Df.art: starke Niederdurchforstung u. BZL
J6551105	Durchforstung: starke Niederdurchfostung und Baumzahlleitkurve
J6551108	Durchforstung: starke Niederdurchfostung und Baumzahlleitkurve
S0651102	0
S1051103	<NA>
S1751101	<NA>
S1851101	<NA>
S1951101	<NA>
S2051102	<NA>
S2151101	<NA>
S2251101	<NA>
S2351103	Schlußaufnahme 2013
S2451102	<NA>
S2551103	<NA>
S2651104	<NA>

5 Archive info per edvid

Table 3: Contents of `edvid.vers.matches`.

…$edvid	…$forstamt	…$abt
05451102	Idarwald	149/150
06451102	Hochstift	990B
07151102	Hochstift	697B
07551103	Westerhof	131b
07551105	Westerhof	131b
11651100	Nationalpark Harz (NDS)	683j
4665111A	SHLF	3532j
4665112B	SHLF	3532j
4665113B	SHLF	3532j
4665114B	SHLF	3532j
4675111A	Grünenplan	66j1
4675112A	Grünenplan	66j1
4675113A	Grünenplan	66j1
4675113B	Grünenplan	66j1
4675114A	Grünenplan	66j1
47451104	Neuhaus	2271j
55751102	Clausthal	1408j/1411j
56151100	Dassel	28j1
61851101	Nationalpark Harz (NDS)	358a1
61851102	Nationalpark Harz (NDS)	358a1
87021515	Clausthal	1100j
87021516	Clausthal	1100j
87021517	Clausthal	1100j
87021520	Clausthal	1100j
87021521	Clausthal	1100j
87021522	Clausthal	1100j
A6251101	Neuhaus	2146j/2149j
A6251104	Neuhaus	2146j/2149j
J5851106	Romrod	1301A2

…$edvid	…$forstamt	…$abt
J6351111	Wehretal	2588A1
J6351121	Wehretal	2588A1
J6351131	Wehretal	2588A1
J6351141	Wehretal	2588A1
J6551105	Bad Hersfeld	190C1
J6551108	Bad Hersfeld	190C1
S0651102	Oberharz	332a1/334h
S1051103	Nationalpark Harz (ST)	137 a3
S1751101	Oberharz	359d5
S1851101	Nationalpark Harz (ST)	137a6
S1951101	Nationalpark Harz (ST)	133 a4
S2051102	Nationalpark Harz (ST)	174a1
S2151101	Nationalpark Harz (ST)	439 a1
S2251101	Nationalpark Harz (ST)	459a\xb2
S2351103	Oberharz	1118 a1
S2451102	Oberharz	483 a2/4
S2551103	Oberharz	257 b6
S2651104	Ostharz	91a4

6 Translation of forestry terminology

Table 4: German and English forestry terminology. Unless otherwise noted, english terminology is taken from Schmid-Haas (1990). Rows should be ordered alphabetically based on 1. column.

German term	English term
Bonität	site class
Beschirmungsgrad	canopy density
Bestand, verbleibender	stand, residual
Bestandesgrundfläche	stand basal area
Bestockungsdichte	density of stocking (The Empire Forestry Association at the Royal Empire Society 1953, p. 38)
Bestockungsgrad	stand density index
Durchforstungsgrad	thinning grade
Durchforstungsstärke	thinning intensity
Ertragsklasse	yield class
Ertragsniveau	production level
Gesamtwuchsleistung	total crop volume (Assmann 1970, p. 152)
Grundfläche	basal area
Grundfläche, maximale	maximum basal area (Assmann 1970, p. 229)
Grundfläche, mittlere	mean basal area (Assmann 1970, p. 216)
Grundflächenhaltung, kritische	basal area over a period, critical (Assmann 1970, p. 229)
Grundflächenhaltung, maximale	basal area, maximum (Assmann 1970, p. 229)
Grundflächenhaltung, mittlere	mean basal area, periodic (Assmann 1970, p. 214); mean basal area over a period (p.m.b.a.) (Assmann 1970, p. 216)
Grundflächenhaltung, optimale	basal area over a period, optimum (Assmann 1970, p. 229)
Hochdurchforstung	thinning from above
Höhenbonität	height quality class (Assmann 1970, p. 159)
Kronenschirmfläche	crown projection (Assmann 1970, p. 157); crown canpoy area (Assmann 1970, p. 158)
Mittelhöhe	height, average
Niederdurchforstung	thinning from below

German term	English term
Oberhöhe	top height
Standort	site
Standortsbonität	site index
Waldmesskunde	forest mensuration

7 Self-thinning line slopes

Table 5: Different slopes of the self-thinning line (i.e., the log(density)-log(diameter)-line of a stand undergoing self-thinning) as reported in the literature for European beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* (L.) H.Karst.).

Source	European beech	Norway spruce
Charru et al. (2012)	−1.941	−1.878
Pretzsch (2006)	−1.873 to −1.723	−1.669 to −1.607
Pretzsch & Biber (2005)	−1.798	−1.664
Sterba (1987)		−1.737
Vacchiano et al. (2013)		−1.497
Vospernik & Sterba (2015)	−1.60 to −1.94	−1.30 to −1.88

8 R Model Benchmarks

8.1 Beech

	model.name	AIC	GCV
1	GAM_gha_sh100.EKL.I_sSI.h100.diff.EKL.I	400.1089	0.02522934
2	GAM_gha_sh100.EKL.I_SI.h100.diff.EKL.I	430.4912	0.04030243
3	GAM_gha_s3h100.EKL.I_SI.h100.diff.EKL.I	432.3091	0.04127329
4	GAM_gha_lhs22h100.EKL.I_SI.h100.diff.EKL.I	442.0630	0.04803858
5	GAM_gha_lhs22h100.EKL.I_rhs22h100.EKL.I_SI.h100.diff.EKL.I	443.3114	0.04909587
6	GAM_gha_lhs27h100.EKL.I_SI.h100.diff.EKL.I	446.0651	0.05116513

	model.name	AIC	GCV
1	SCAM_gha_micvh100.EKL.I_SI.h100.diff.EKL.I	442.7291	0.04861338
2	SCAM_gha_mpih100.EKL.I_SI.h100.diff.EKL.I	445.2228	0.05068639

	model.name	AIC
1	GAMLSS_gha_ps1h100.EKL.I_psSI.h100.diff.EKL.I	379.0241
2	GAMLSS_gha_psh100.EKL.I_psSI.h100.diff.EKL.I	380.1885
3	GAMLSS_gha_ps1h100.EKL.I_SI.h100.diff.EKL.I	398.2788
4	GAMLSS_gha_psh100.EKL.I_SI.h100.diff.EKL.I	399.3185
5	GAMLSS_gha_pbmh100.EKL.I_SI.h100.diff.EKL.I	412.5997
6	GAMLSS_gha_lhs27h100.EKL.I_SI.h100.diff.EKL.I	415.5894
7	GAMLSS_gha_lhs22h100.EKL.I_SI.h100.diff.EKL.I	419.0971
8	GAMLSS_gha_lhs22h100.EKL.I_rhs22h100.EKL.I_SI.h100.diff.EKL.I	420.7220

8.2 Spruce

```
                                                       model.name      AIC        GCV
1 GAM_gha_sh100.EKL.I_sSI.h100.diff.EKL.I                        705.9977 0.02945132
2 GAM_gha_sh100.EKL.I_SI.h100.diff.EKL.I                         718.0582 0.03267823
3 GAM_gha_s3h100.EKL.I_SI.h100.diff.EKL.I                        743.5174 0.04190867
4 GAM_gha_lhs22h100.EKL.I_rhs22h100.EKL.I_SI.h100.diff.EKL.I 748.4529 0.04401745
5 GAM_gha_lhs27h100.EKL.I_SI.h100.diff.EKL.I                     753.9866 0.04646375
6 GAM_gha_lhs22h100.EKL.I_SI.h100.diff.EKL.I                     757.1280 0.04793549
```

```
                                       model.name      AIC       GCV
1 SCAM_gha_mpih100.EKL.I_SI.h100.diff.EKL.I  713.9900 0.0313731
2 SCAM_gha_micvh100.EKL.I_SI.h100.diff.EKL.I 717.1438 0.0322761
```

```
                                                          model.name      AIC
1 GAMLSS_gha_pbmh100.EKL.I_SI.h100.diff.EKL.I                        705.3113
2 GAMLSS_gha_psh100.EKL.I_psSI.h100.diff.EKL.I                       707.1247
3 GAMLSS_gha_ps1h100.EKL.I_psSI.h100.diff.EKL.I                      709.6035
4 GAMLSS_gha_psh100.EKL.I_SI.h100.diff.EKL.I                         710.2802
5 GAMLSS_gha_ps1h100.EKL.I_SI.h100.diff.EKL.I                        714.0636
6 GAMLSS_gha_lhs22h100.EKL.I_rhs22h100.EKL.I_SI.h100.diff.EKL.I 747.1909
7 GAMLSS_gha_lhs22h100.EKL.I_SI.h100.diff.EKL.I                      747.8617
8 GAMLSS_gha_lhs27h100.EKL.I_SI.h100.diff.EKL.I                      754.3935
```

References

Assmann E. 1961. Waldertragskunde. Organische Produktion, Struktur, Zuwachs und Ertrag von Waldbeständen. München, Bonn, and Wien.

Assmann E. 1970. The principles of forest yield study. Studies in the organic production, structure, increment and yield of forest stands. Oxford et al.

Charru M., Seynave I., Morneau F., Rivoire M. and Bontemps J.-D. 2012. Significant differences and curvilinearity in the self-thinning relationships of 11 temperate tree species assessed from forest inventory data. Annals of Forest Science 69, 195–205. DOI: 10.1007/s13595-011-0149-0

Pretzsch H. 2006. Species-specific allometric scaling under self-thinning: evidence from long-term plots in forest stands. Oecologia 146, 572–583. DOI: 10.1007/s00442-005-0126-0

Pretzsch H., Biber P. 2005. A Re-Evaluation of Reineke's Rule and Stand Density Index. Forest Science 51, 304–320

Schmid-Haas P. 1990. Vocabulary of Forest Management. IUFRO World Series Nr. 1. Vienna.

Sterba H. 1987. Estimating Potential Density from Thinning Experiments and Inventory Data. Forest Science 33, 1022–1034

The Empire Forestry Association at the Royal Empire Society 1953. British Commonwealth Forest Terminology. London.

Vacchiano G., Derose R. J., Shaw J. D., Svoboda M. and Motta R. 2013. A density management diagram for Norway spruce in the temperate European montane region. European Journal of Forest Research 132, 535–549. DOI: 10.1007/s10342-013-0694-1

Vospernik S., Sterba H. 2015. Do competition-density rule and self-thinning rule agree? Annals of Forest Science 72, 379–390. DOI: 10.1007/s13595-014-0433-x