



Using R as an environment for automatic extraction of forest growth parameters from terrestrial laser scanner data



Dortmund

13.08.2008

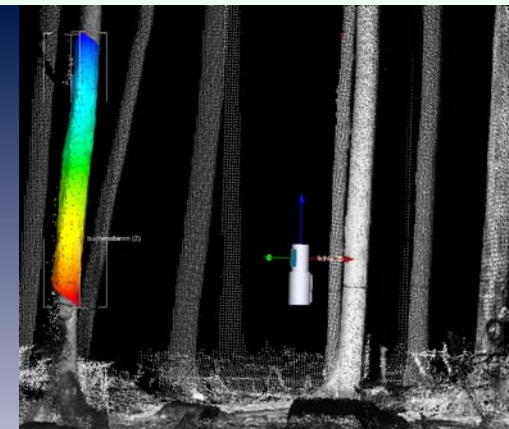
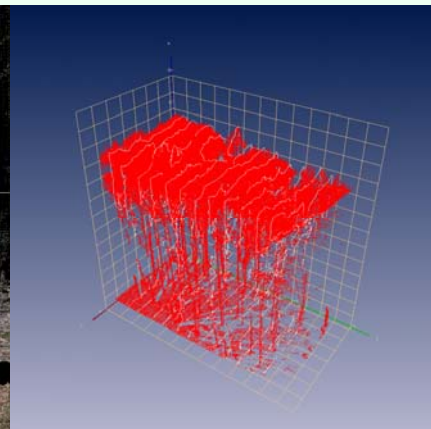
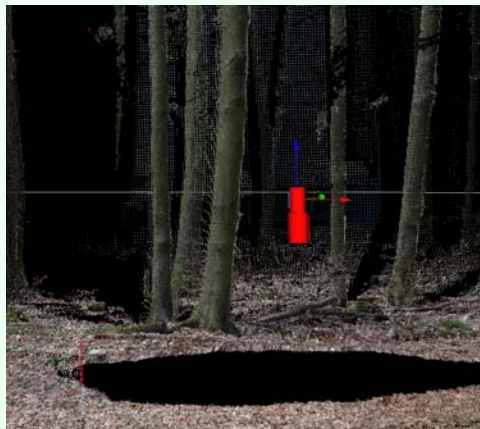
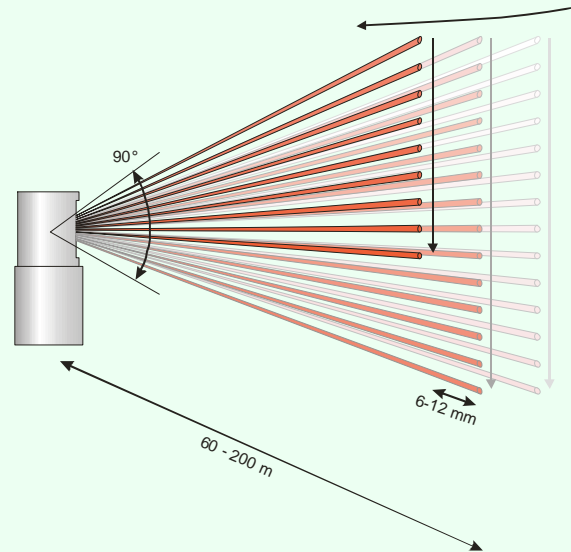
Dr. Hans-Joachim Klemmt



Contents

- Introduction
- Relevant parameters for forest inventory purposes
 - Determination of stem positions
 - Calculation of tree heights
 - Estimation of diameters in breast height (DBH)
 - Calculation of volume of stem axis
- Performance of the developed system (case study „Selb“)
- Summary and perspectives

Terrestrial Laserscanner



R-Package „RLaserForest“

The screenshot displays the RGui environment with the following components:

- R Console:** Contains R code for processing laser data. Key lines include:

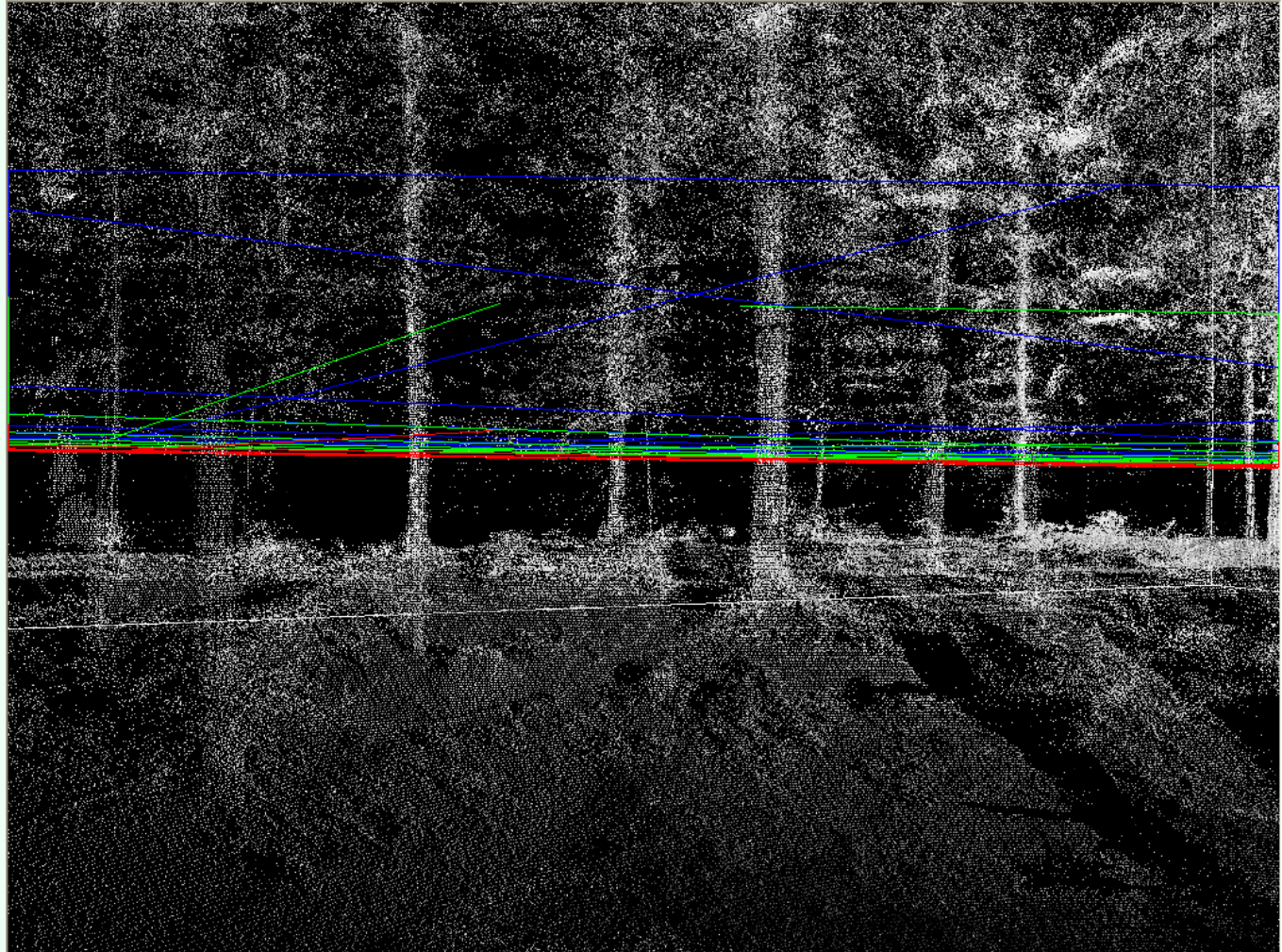

```

      + #print(paste("Abschnitt: ", i/10, "-", (i$
      + )#eo for
      >
      > #last but not least: die errechneten Wert$
      > screen(3)
      > Ergebnisausgabe<-paste(Ergebnisausgabe, "$
      > Ergebnisausgabe<-paste(Ergebnisausgabe, "$
      > Ergebnisausgabe<-paste(Ergebnisausgabe, "$
      > text(0.5,0.5,Ergebnisausgabe, cex=0.65)
      >
      R:\Arbeit\Tauber_Selb\Durchmesser_Einzelbaum\Durchmesser_Einzel
      for(i in 1:st1)
      {
      pt2<-seq(i/10, (i/10)+0.1, len=2) #10cm-Abschnitt
      Wert<-predict(fm1, data.frame(Messhoehe=pt2))
      rotationskoerper<-((Wert[1]+Wert[2])/2)^2*0.1*pi
      schaftholzvolumen<-schaftholzvolumen+rotationskoer
      if(Wert[1]>=0.035)
      {
      schaftderbholzvolumen<-schaftderbholzvolumen+ro
      }
      #print(paste("Abschnitt: ", i/10, "-", (i/10)+0.1, "I
      )#eo for
      #last but not least: die errechneten Werte oben links
      screen(3)
      Ergebnisausgabe<-paste(Ergebnisausgabe, "\nSchaftvolumen: ")
      Ergebnisausgabe<-paste(Ergebnisausgabe, "Schaftderbholzvolumen: ")
      Ergebnisausgabe<-paste(Ergebnisausgabe, "\n--- Ende automatisierte Auswertung ---")
      text(0.5,0.5,Ergebnisausgabe, cex=0.65)
      ### Bildschirmteilung beenden
      close.screen(all = TRUE) # exit split-screen mode
      
```
- R Graphics: Device 2 (ACTIVE):** Displays a table of tree parameters and a 3D visualization.

Height [m]	Radius [m]	Volume [m³]
1	0.4684	0.02942
2	0.4576	0.0279
3	0.4488	0.02804
4	0.4444	0.03027
5	0.4312	0.04706
6	0.4246	0.02315
7	0.4202	0.03945
8	0.418	0.03373
9	0.418	0.09456
10	0.3872	0.02957
15	6.7474	3.27638
20	2.0394	5.01945
25	2.9018	15.93948
30	2.178	0.19213

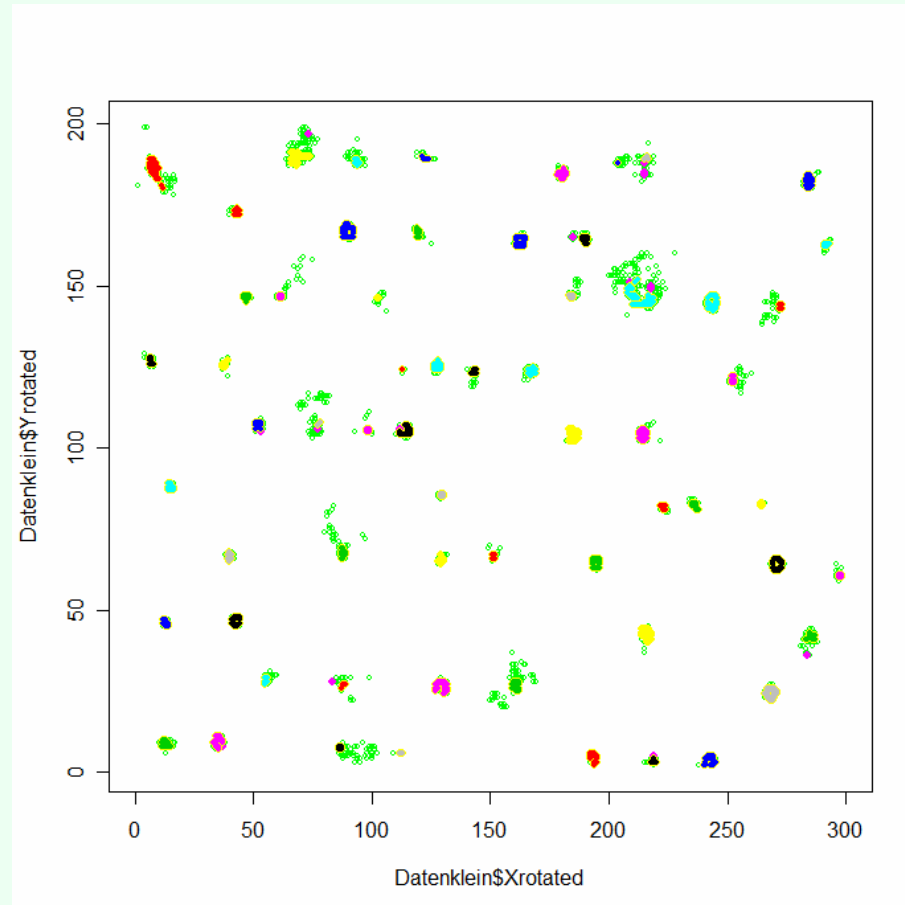
Stammlaenge: 33.421 (m)
Brusthoehendurchmesser: 0.484 [m]
Schaftvolumen [m³]: 2.2315
Schaftderbholzvolumen [m³]: 2.2268
--- Ende automatisierte Auswertung ---
- 3D Plot:** A 3D visualization of a tree trunk with a green vertical line representing the stem. The axes are labeled X.m., Y.m., and Z.m.
- 2D Plot:** A line graph showing the relationship between Radius [m] (y-axis, 0.00 to 0.20) and Messhoehe [m] (x-axis, 0 to 25). The radius decreases as height increases.

R-Package R LaserForest: Determination of stem positions (slide 1)

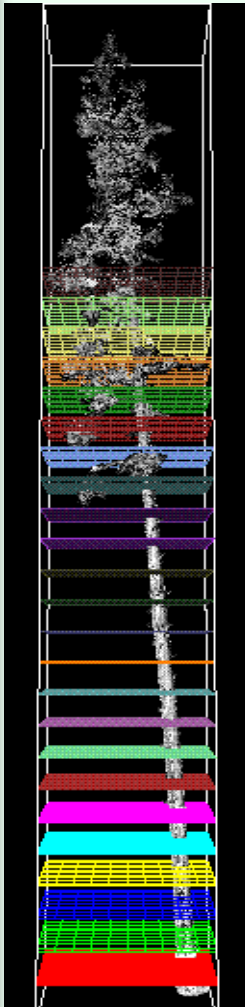




R-Package R LaserForest: Determination of stem positions (slide 2)



R-Package R LaserForest: Height calculation and Determination of diameters in breast height (DBH)



RGui

Datei Bearbeiten Pakete Windows Hilfe

R Console

```
Mean :0.1652
3rd Qu.:0.1771
Max. :0.2026

> res$coefficients
      r      a      b
0.1652077 -10.9095916 31.5687572
> #plot(res, main="Schnittebene 5 m", cex=0.75)
> #Ergebnisausgabe<-paste(Ergebnisausgabe, "Durchmess
>
> #
> # E
> # A
> # F
> # F
+ {
+ B pt2<-seq(1/10, (i/10)+0.1, len=2) #10cm-
+ S Wert<-predict(fm1, data.frame(Messhoehe=pt
+ r rotationskoerper<-((Wert[1]+Wert[2])/2)^2*(
+ E schaftholzvolumen<-schaftholzvolumen+rotat
+
+
+ if(Wert[1]>=0.035)
+ E {
+ E schaftderbholzvolumen<-schartderbholzvo
+
+
+ #print(paste("Abschnitt: ", i/10, "-", (i/10)
+ })#eo for

#last but not least: die errechneten Werte ob
screen(3)
Ergebnisausgabe<-paste(Ergebnisausgabe, "\nSch
Ergebnisausgabe<-paste(Ergebnisausgabe, "Scha
Ergebnisausgabe<-paste(Ergebnisausgabe, "\n---
text(0.5,0.5,Ergebnisausgabe, cex=0.65)

### Bildschirmteilung beenden
close.screen(all = TRUE) # exit split-scre
```

R Graphics: Device 2 (ACTIVE)

Schnittebene 1 m (~BHD)

Z.m.

X.m.

Y

X

Y.m.

R-Package RLaserForest: Calculation of stem volume

The screenshot displays the RGui interface with the following components:

- R Console:** Contains R code for calculating stem volume. The code iterates through tree segments (1 to 30), calculates the radius at each segment, and sums the volumes of the stem and rotation bodies.
- R Graphics: Device 2 (ACTIVE):** Shows a table of tree measurements and a 3D visualization of a tree.

Segment (Dm)	Height (m)	Radius (m)	Volume (m³)
1	0.3938	0.01354	
2	0.3894	0.01537	
3	0.3894	0.02746	
4	0.3696	0.01627	
5	0.363	0.01205	
6	0.3652	0.01463	
7	0.3564	0.0221	
8	0.3564	0.0143	
9	0.4224	0.23664	
10	15.2394	4.71262	
15	2.9436	14.38858	
20	4.2922	61.18209	
25	2.5278	5.25527	
30	1.144	0.23179	

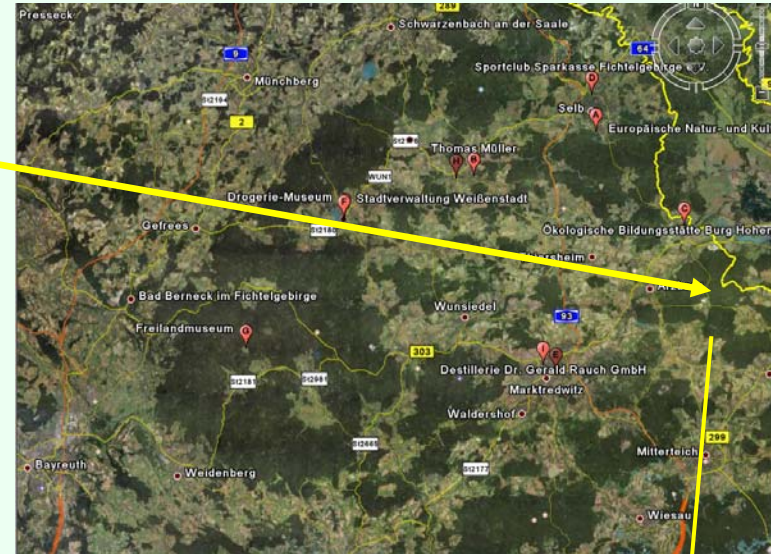
Summary statistics from the graphics window:

- Stammlaenge: 33.685 (m)
- Brusthoehendurchmesser: 0.4004 (m)
- Schaftvolumen [m³]: 1.7172
- Schaftderbholzvolumen [m³]: 1.7121

The 3D model shows a tree with a green stem and a red base, plotted on a coordinate system with X, Y, and Z axes.



case study „Selb“



9/ 17

50°09'12" N

12°11'55" O

Images of case study stand





description of data

measurement in field

- 37 Norway spruce trees + 13 Scots pine trees

Applicated in RLaserForest

37 Norway spruce trees + 9 Scots pine trees

Norway spruce: mean DBH 38,54 cm (20,65-61,25cm); mean height: 30,9m (21,35-38,32)

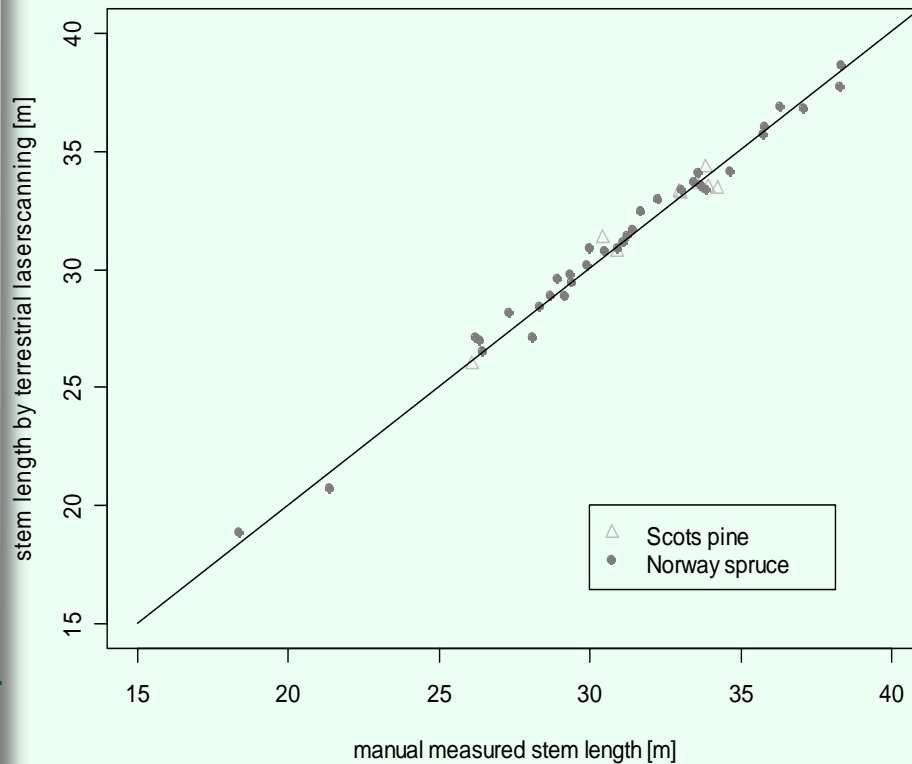
Scots pine: mean DBH 38,07 cm (31,25-49,9cm); mean height: 32,10m (26,08-34,22)



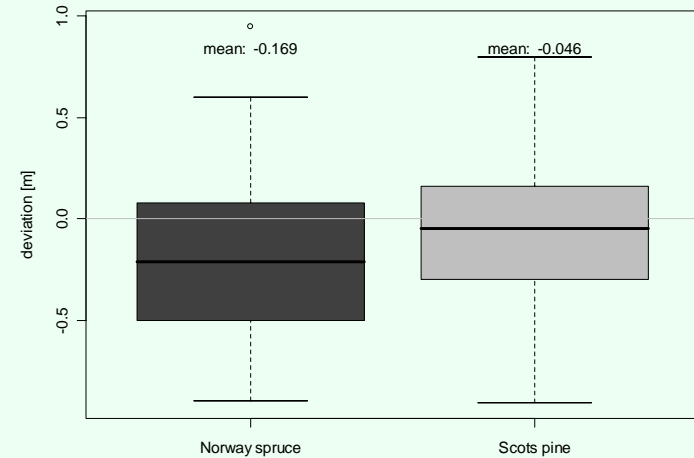
Results (case study „Selb“)

here: length of stems

Manual measured stem length vs. Terrestrial laserscanner stem length



Deviation between manual and terrestrial laser stem length measurement

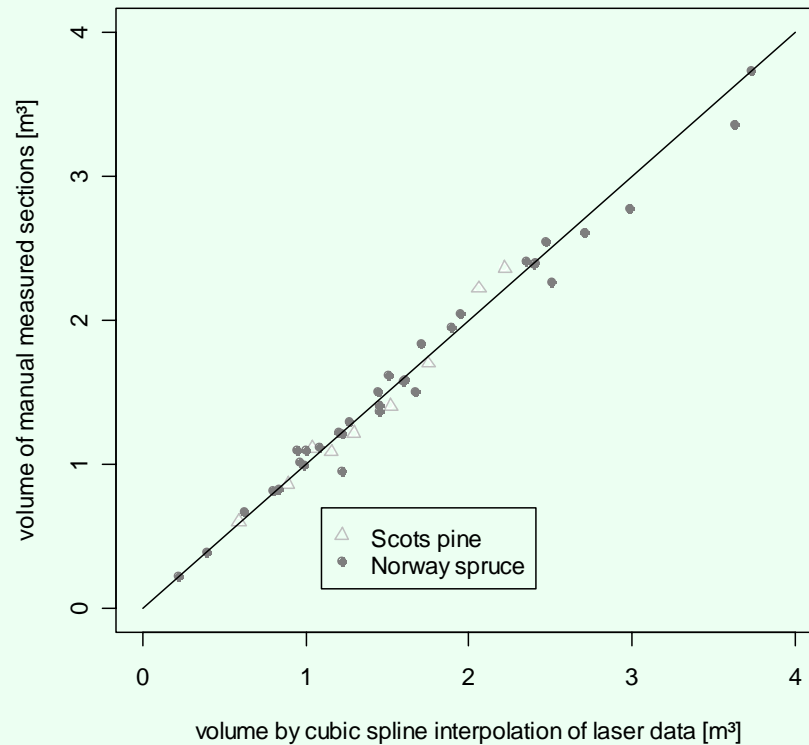




Results (case study „Selb“)

here: volume of stem axis

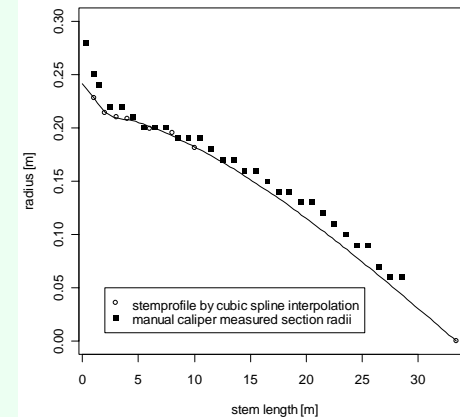
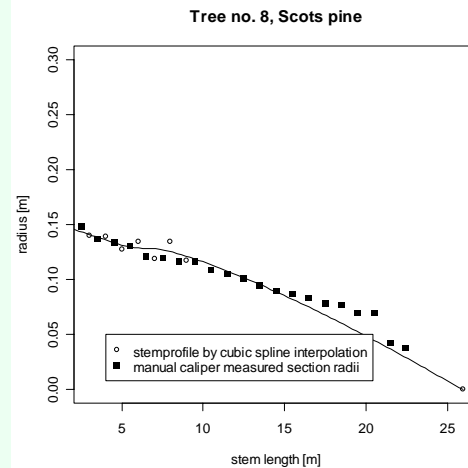
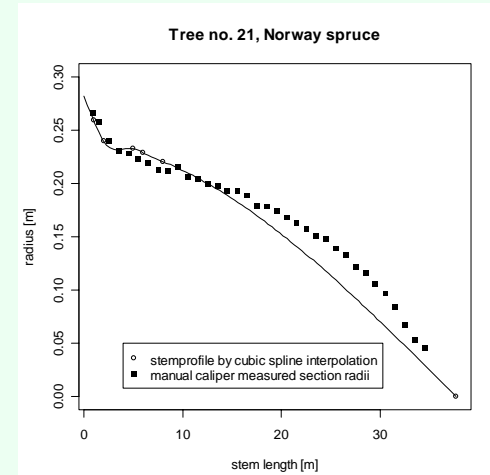
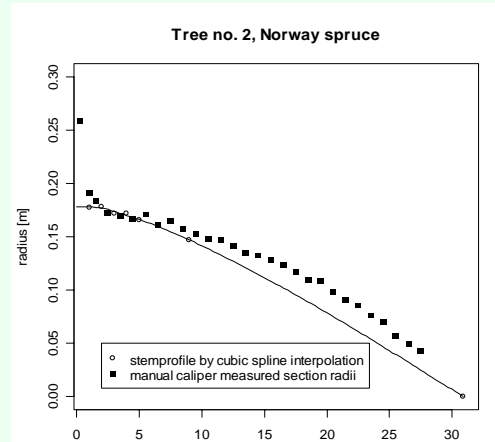
calculated in sections vs. volume by quadrature of cubic spline





Results

here: attempt to explain the deviation between real and calculated volume





Summary and perspectives

TODOs: improvement of volume calculation
improvement of diameter estimation for excentric stems
afterwards: automated determination of tree species (classification)
afterwards: automated separation of crown parameters (spectral clustering)

Objective: modular built R-Package „RLaserForest“ for automatic extraction of forest growth relevant inventory parameters by the use of the statistic programming language R



I want to say thank you to:

- BaySF: Forstbetrieb Selb (insbes. Herrn Michael Grosch und Herrn Hubert Fellermeier) for enabling case study in field
- LfWwk: Herrn Stefan Seifert, Herrn Thomas Seifert, Herrn Istvan Pal, Herrn Gerhard Schütze, Frau Andrea Oumeddah as well as Herrn Sebastian Seibold and Herrn Martin Stary
- colleagues from FMI UHUL from Czech republic
(cooperation within a common Interreg IIIa-project)



Thank you very much for your
attention!



I am looking forward to a fruitful discussion ...