Biomass estimation on 1 ha FOS Lacosa data

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Load data

```
library(BIOMASS)

# REMOVE DEAD TREES AND CONSIDER ONLY NUMERIC VALUES IN HEIGHT MEASUREMENTS
FosData<-read.csv("LacosaHDalive.csv",header=TRUE, sep=",", dec=".")

# DUBIOUS VALUES IN TREE HEIGHT: tree height values < 1.3 m are surpising if the POM is at 1.3
 m and 90 m would be the tallest register tree from the tropics
summary(FosData$H)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    1.10   11.80   15.30   17.05   20.70   95.00
```

```
# ERRORS IN TREE DIAMETER: Six values < 10 cm dbh
sum(FosData$D<10,na.rm =T)
```

```
## [1] 6
```

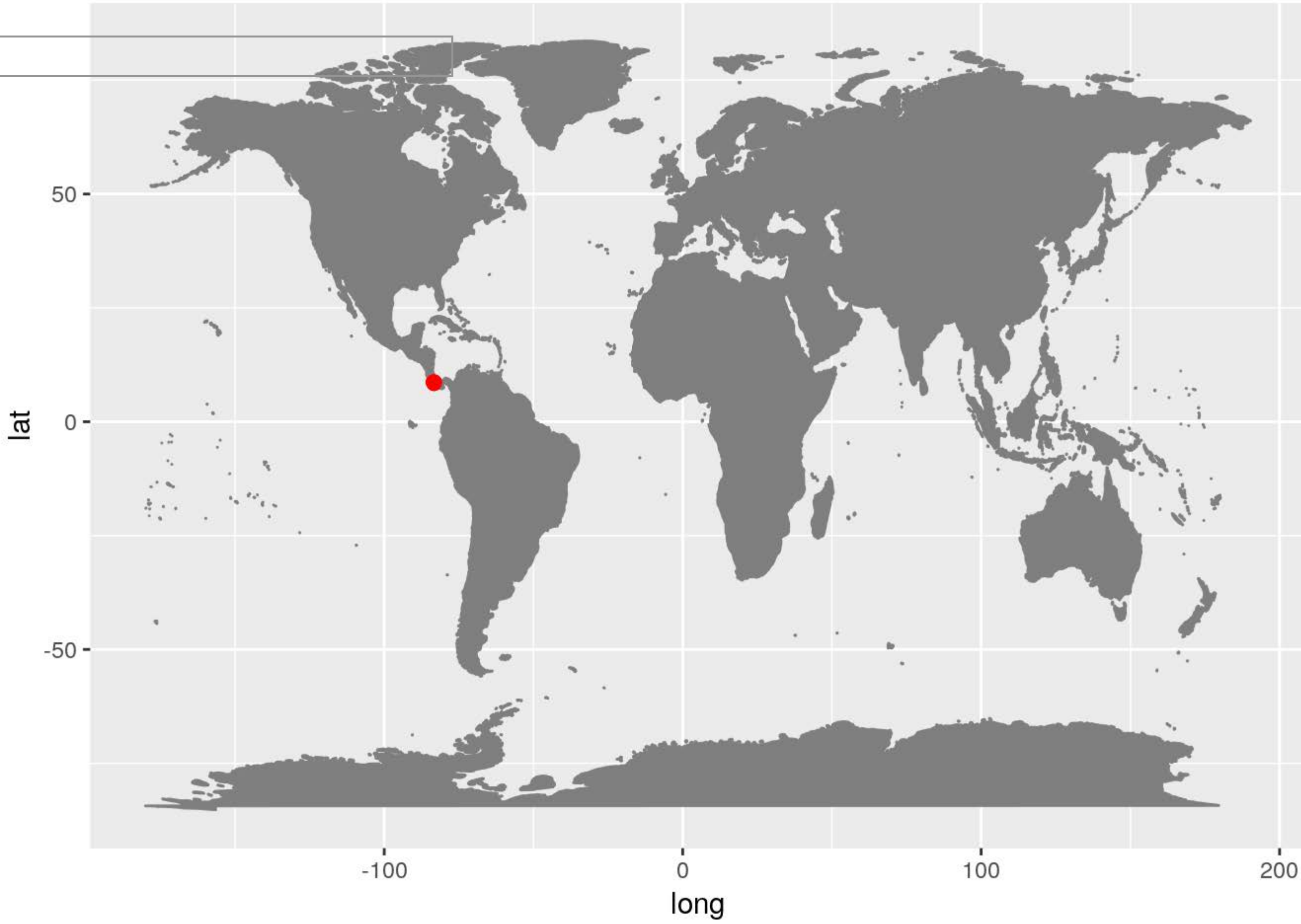
```
FosData<-FosData[FosData$D>=10,]

# Longitude should be negative
FosData$Long<- -FosData$long
FosData$Lat<-FosData$lat

# Carefull: "plotId"" is not an ID of plot, this is in fact a "treeId""
length(unique(FosData$plotId))
```

```
## [1] 11774
```

```
# Remove NA values
FosData<-FosData[!is.na(FosData$PlotCode),]
```

Location of the plots

Loading [MathJax]/jax/output/HTML-CSS/jax.js



Retrieve wood density

```
## [1] "Calling http://taxosaurus.org/retrieve/4dd78acb643d8b01e6b8ac201a2af280"
## [1] "Calling http://taxosaurus.org/retrieve/2e976c4c0b337e6ff01e797fb623e9d9"
## [1] "Calling http://taxosaurus.org/retrieve/73dbf4da1d86997f2af6b5a417786fb9"
## [1] "Calling http://taxosaurus.org/retrieve/7c77be3ca59495c2a874d21886f4e660"
## [1] "Calling http://taxosaurus.org/retrieve/e41ba7747c62edfe9d72323494300f3d"
## [1] "Calling http://taxosaurus.org/retrieve/6eea9cc2695423768ba3a085b919fa06"
## [1] "Calling http://taxosaurus.org/retrieve/e97c4b69534aba8374fdc8824103fb41"
## [1] "Calling http://taxosaurus.org/retrieve/5a4389539dce9eded36b3e8a4e2bd882"
## [1] "Calling http://taxosaurus.org/retrieve/f9fb1a927a63fe35bfa06ec6b4f1b9fb"
## [1] "Calling http://taxosaurus.org/retrieve/9233bb7317df15c9992282a6ccff7f64"
## [1] "Calling http://taxosaurus.org/retrieve/3f87c24c3f03d1b6431584359f677b1e"
## [1] "Calling http://taxosaurus.org/retrieve/fda1b8205eb2bf6d879931b5f9a1d84f"
## [1] "Calling http://taxosaurus.org/retrieve/6b7e44da010304a972d3945a6cafba70"
## [1] "Calling http://taxosaurus.org/retrieve/eaeed21c8a9fbf113bdd06ab4141e1f4"
## [1] "Calling http://taxosaurus.org/retrieve/80a62c9506f992be4f60fed244a77f3d"
## [1] "Calling http://taxosaurus.org/retrieve/64b9dddbbdcc40726eafd33f4e3aa613"
## [1] "Calling http://taxosaurus.org/retrieve/1525bb6ce68f2a2e759b1eab0403829d"
```

```
# Retrieve wood density
dataWD<-getWoodDensity(genus=tax.cor$genusCorrected,
                       species=tax.cor$speciesCorrected,
                       stand=FosData$PlotCode)
```

```
## The reference dataset contains 16467 wood density values
## Your taxonomic table contains 488 taxa
```

```
FosData$WD=dataWD$meanWD
FosData$sdWD=dataWD$sdWD
```

Overall, 53.4 % of the values have been attributed at the species level, 23.9 % at the genus level, and 22.7 % at the plot level.

Construct H-D models

We implemented a three parameter weibull model of the form:

$$H = a \quad (1 - exp(-(D/b)^c))$$

where *a* represents the asymptotic height of trees in the stand. Note that the model is fitted by giving a proportional weight to the volume of trees (proportional to D^2*H).

```
# Number of tree height data per plot
ntree <- tapply(FosData$H,FosData$PlotCode,function(x) length(x[!is.na(x)]))
ntree
```

```
## AB-RiPF  AB-RPF   AB-SF  AB-SPF LG-RiPF  LG-RPF   LG-SF  LG-SPF  P-RiPF
##     636     640     436     571     639     754     618     689     541
##   P-RPF    P-SF   P-SPF  R-RiPF   R-RPF    R-SF   R-SPF RQ-RiPF  RQ-RPF
##     452     499     524     477     622     524     785     504     682
##   RQ-SF  RQ-SPF
##     494     689
```

```
# Compute models specific to given stands (those having a minimum of 30 measured trees)
modelHDperplot <- by(FosData,FosData$PlotCode,
function(x) modelHD(D=x$D,H=x$H, method="weibull",useWeight =T),
simplify=F)
RSEmodels<-sapply(modelHDperplot,function(x) x$RSE)
Coeffmodels<-lapply(modelHDperplot,function(x) x$coefficients)
ResHD<-data.frame(Plot=names(unlist(RSEmodels)),
                  a=round(unlist(sapply(Coeffmodels,"[",1)),3),
                  b=round(unlist(sapply(Coeffmodels,"[",2)),3),
                  c=round(unlist(sapply(Coeffmodels,"[",3)),3),
                  RSE=round(unlist(RSEmodels),3))
```

Plot	a	b	c	RSE
AB-RiPF	45.880	36.225	0.988	5.537
AB-RPF	111.365	371.254	0.531	6.400
AB-SF	33.615	22.734	1.069	4.716
AB-SPF	1497.282	117961.329	0.495	5.747
LG-RiPF	39.302	34.880	1.020	4.552
LG-RPF	38.569	28.916	1.223	4.972
LG-SF	1188.869	107953.963	0.496	3.962
LG-SPF	38.046	33.463	0.942	4.821

P-RiPF	115.295	527.414	0.533	5.080
P-RPF	48.124	64.612	0.583	4.227
P-SF	59.730	78.629	0.694	5.116
P-SPF	75.356	137.515	0.667	4.078
R-RiPF	44.613	36.213	1.033	5.568
R-RPF	60.426	61.958	0.753	4.586
R-SF	28.249	17.967	1.480	4.304
R-SPF	34.754	26.880	1.066	4.549
RQ-RiPF	37.644	24.374	1.334	5.805
RQ-RPF	49.552	70.338	0.673	3.800
RQ-SF	3872.948	174164.365	0.598	7.044
RQ-SPF	32.989	26.652	1.294	4.739

Weibull parameters are unrealistic for some plots (e.g. assymptotic height > 1000 m).

```
# retrieving predicted height values in the database
FosData$Hlocal<-FosData$H # keeping directly measured trees
FosData$HlocalRSE<- 1 # to be refined?! Assume a 1-m error on directly measured trees

Plot=as.character(ResHD$Plot)
for(i in 1:length(ResHD$Plot)){
  filt<-FosData$PlotCode==Plot[i] & is.na(FosData$Hlocal)
  FosData$Hlocal[filt]<-retrieveH(D=FosData$D[filt],model=modelHDperplot[[Plot[i]]])$H
  FosData$HlocalRSE[filt]<-modelHDperplot[[Plot[i]]]$RSE
}
```

Estimating biomass and associated uncertainties

Below, we used a Bayesian Monte-Carlo scheme to estimate the mean AGB and associated credibility interval per plot.

Using a local H-D model for all plots with at least 30 height measurements

```
resultMClocal<- by(FosData,FosData$PlotCode,
              function(x)AGBmonteCarlo(D=x$D,
                               WD=x$WD,
                               H=x$Hlocal,
                               errWD =x$sdWD,
                               errH=x$HlocalRSE,
                               Dpropag ="chave2004"),
              simplify=FALSE)

credperplotlocal<-t(as.data.frame(sapply(resultMClocal,"[",4)))
ResHDlocal<-data.frame(Plot=names(resultMClocal),
                    AGB=round(unlist(sapply(resultMClocal,"[",1)),1),
                    Cred_2.5=round(credperplotlocal[,"2.5%"],1),
                    Cred_97.5=round(credperplotlocal[,"97.5%"],1))
```

Plot	AGB	Cred_2.5	Cred_97.5
AB-RiPF	330.4	303.0	360.3

AB-RPF	485.1	445.3	531.7
AB-SF	234.8	215.9	256.4
AB-SPF	438.5	396.3	491.3
LG-RiPF	196.0	178.7	215.6
LG-RPF	302.3	274.8	334.9
LG-SF	173.5	158.0	194.3
LG-SPF	244.8	224.5	267.6
P-RiPF	355.6	324.2	393.8
P-RPF	297.3	271.2	327.0
P-SF	234.1	206.9	269.7
P-SPF	333.1	299.3	375.1
R-RiPF	293.7	264.7	323.5
R-RPF	330.4	306.0	358.0
R-SF	125.6	117.1	134.8
R-SPF	301.3	278.8	326.4
RQ-RiPF	239.2	214.7	267.5
RQ-RPF	280.2	259.5	304.0
RQ-SF	175.1	158.6	194.6
RQ-SPF	285.5	261.3	311.6

Using Feldpausch et al. 2012 regional Weibull models

```
# Retrieving height
HeightFeldpausch<-retrieveH(D=FosData$D,region="ECAmazonia")
FosData$Hfeld<-HeightFeldpausch$H
FosData$RSEfeld<-HeightFeldpausch$RSE

# Retrieving agb per plot
resultMCfeld<-by(FosData, FosData$PlotCode,
              function(x) AGBmonteCarlo(D=x$D,WD=x$WD,errWD=x$sdWD,H=x$Hfeld,
                                        errH=x$RSEfeld,Dpropag ="chave2004"),
              simplify=F)
credperplotfeld<-t(as.data.frame(sapply(resultMCfeld,"[",4)))

ResFeld<-data.frame(Plot=names(resultMCfeld),
                    AGB=round(unlist(sapply(resultMCfeld,"[",1)),1),
                    Cred_2.5=round(credperplotfeld[,"2.5%"],1),
                    Cred_97.5=round(credperplotfeld[,"97.5%"],1))
```

Plot	AGB	Cred_2.5	Cred_97.5
AB-RiPF	300.5	273.8	327.1
AB-RPF	446.2	406.7	488.2
AB-SF	244.3	217.7	274.8
AB-SPF	417.2	374.5	467.6
LG-RiPF	205.4	186.6	226.3
LG-RPF	298.0	267.0	334.1
LG-SF	191.6	173.8	216.3
LG-SPF	257.7	234.5	282.7
P-RiPF	372.3	338.4	413.2

P-RPF	318.8	289.1	351.8
P-SF	223.7	197.3	257.7
P-SPF	327.8	290.5	372.9
R-RiPF	284.2	255.1	316.4
R-RPF	285.5	261.8	314.5
R-SF	127.4	117.5	138.3
R-SPF	310.2	284.2	341.3
RQ-RiPF	237.3	210.2	269.0
RQ-RPF	305.2	280.0	331.5
RQ-SF	184.0	166.4	204.8
RQ-SPF	316.6	289.0	346.0

Using Chave et al. 2014 Equation 7 model

```
# Retrieving agb per plot
resultMCchave<-by(FosData, FosData$PlotCode,
              function(x) AGBmonteCarlo(D=x$D,WD=x$WD,errWD=x$sdWD,
                                        coord=cbind(x$Long,x$Lat),
                                        Dpropag ="chave2004"),
              simplify=F)
credperplotchave<-t(as.data.frame(sapply(resultMCchave,"[",4)))
ResChave<-data.frame(Plot=names(resultMCchave),
                    AGB=round(unlist(sapply(resultMCchave,"[",1)),1),
                    Cred_2.5=round(credperplotchave[,"2.5%"],1),
                    Cred_97.5=round(credperplotchave[,"97.5%"],1))
```

Plot	AGB	Cred_2.5	Cred_97.5
AB-RiPF	332.5	299.1	369.3
AB-RPF	491.7	440.1	554.9
AB-SF	275.6	243.7	315.7
AB-SPF	461.4	403.4	526.8
LG-RiPF	236.7	213.7	264.0
LG-RPF	345.5	304.7	395.9
LG-SF	223.2	200.7	252.0
LG-SPF	298.0	270.5	329.7
P-RiPF	414.3	370.4	468.1
P-RPF	356.3	316.8	402.2
P-SF	254.5	221.8	296.5
P-SPF	368.9	324.7	423.7
R-RiPF	331.9	293.1	372.9
R-RPF	329.8	297.6	365.8
R-SF	152.6	139.6	166.9
R-SPF	358.8	325.2	395.0
RQ-RiPF	266.0	231.8	308.2
RQ-RPF	336.6	307.0	369.9
RQ-SF	205.7	184.3	229.6
RQ-SPF	354.5	319.5	396.2

```
# Calculating the maximum height and the Lorey's height per (sub)plot
FosData$Hchave<-retrieveH(D=FosData$D,coord=cbind(FosData$Long,FosData$Lat))$H
```

```
# Max height
maxHlocal<-tapply(FosData$Hlocal,FosData$PlotCode,max)
maxHchave<-tapply(FosData$Hchave,FosData$PlotCode,max)
maxHfeld<- tapply(FosData$Hfeld,FosData$PlotCode,max)

# Lorey height
FosData$BAm<-(pi*(FosData$D/2)^2)/10000
FosData$HBAlocal<-FosData$Hlocal*FosData$BAm
FosData$HBAchave<-FosData$Hchave*FosData$BAm
FosData$HBAfeld<-FosData$Hfeld*FosData$BAm
LoreyLocal<-tapply(FosData$HBAlocal,FosData$PlotCode,sum)/tapply(FosData$BAm,FosData$PlotCode,
sum)
LoreyChave<-tapply(FosData$HBAchave,FosData$PlotCode,sum)/tapply(FosData$BAm,FosData$PlotCode,
sum)
LoreyFeld<-tapply(FosData$HBAfeld,FosData$PlotCode,sum)/tapply(FosData$BAm,FosData$PlotCode,su
m)

meanWD<-tapply(FosData$WD,FosData$PlotCode,mean)
```