Estimate height

```
source(here::here("load_pkgs.R"))
```

Explore data

```
tree <- read_csv(here::here("data/tree_data.csv"), col_types = cols())

tree %>% group_by(sp) %>%
  count(is.na(h)) %>%
  spread(`is.na(h)`, n) %>%
  rename(n=`FALSE`, n_na = `TRUE`) %>%
  knitr::kable()
```

```
## group_by: one grouping variable (sp)

## count: now 9 rows and 3 columns, one group variable remaining (sp)

## spread: reorganized (is.na(h), n) into (FALSE, TRUE) [was 9x3, now 8x3]

## rename: renamed 2 variables (n, n_na)
```

sp	n	n_na
Adec	1	NA
Aopa	6	NA
Cmon	37	NA
Pdul	9	NA
Pter	9	NA
Qilex	NA	3
Qpyr	2738	664
Saria	18	NA

Trees with no values for height belongs to *Q. ilex* and *Q. pyrenaica*. Height data for computation of *Q. ilex* biomass is not needed according to allometric equation proposed by Ruiz-Peinado, Montero, and Del Rio (2012). For *Q. pyrenaica* and estimation of height values was done using non-linear squares model. We used the best equation according to Adame, del Río, and Cañellas (2008)

$$h = 1.3 + a * \exp(b/dbh)$$

Model height-diameter

```
# see pag. 391 from @PommereningGrabarnik2019IndividualbasedMethods
# See @Adameetal2008MixedNonlinear for equations. The best equation is
# h ~ 1.3 + a*e^(b/D)
# start values from @Adameetal2008MixedNonlinear

# Remove data withouth dbh
df_model <- tree %>%
  filter(sp == "Qpyr") %>%
  filter(!is.na(h))
```

```
## filter: removed 83 rows (2%), 3,402 rows remaining
```

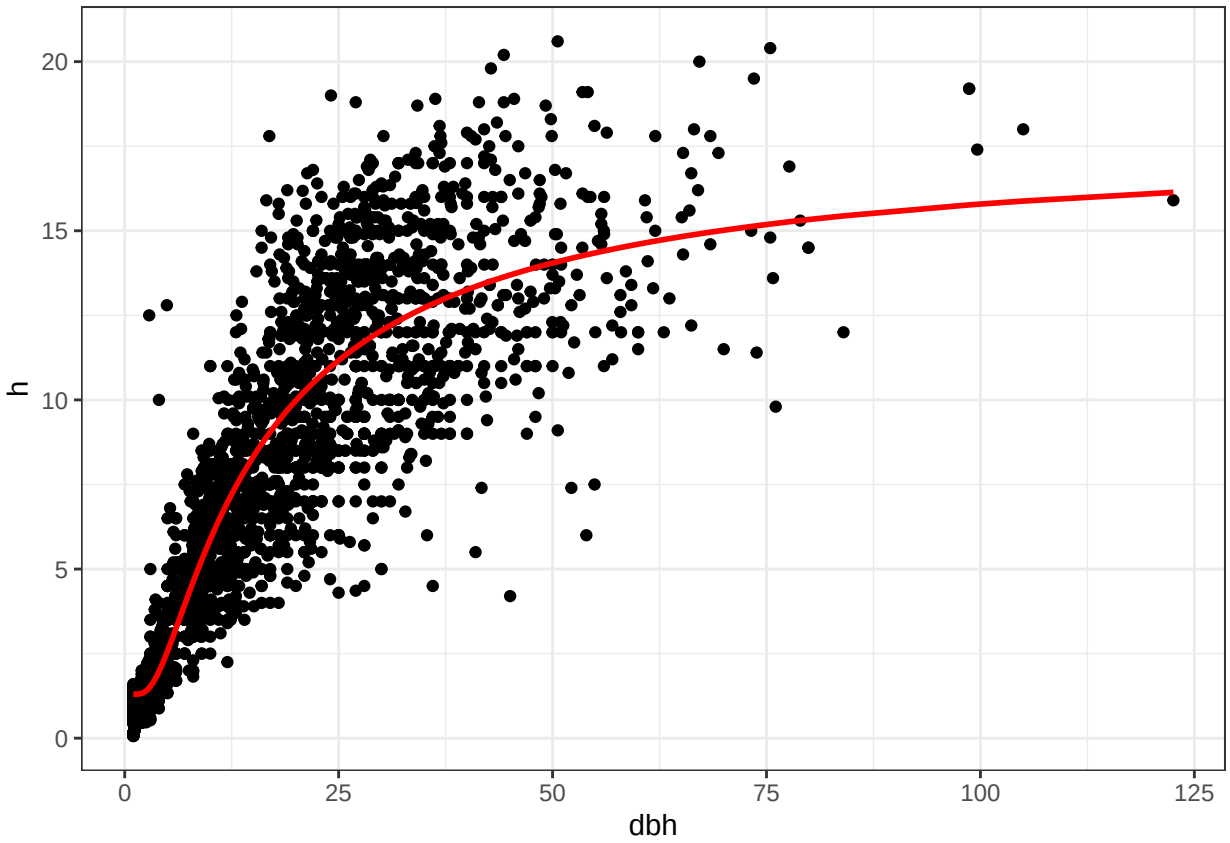
```
## filter: removed 664 rows (20%), 2,738 rows remaining
```

```
# NonLinear Least Squares
m <- nls(h ~ 1.3 + a * exp(b / dbh),
         data = df_model,
         start = list(a = 15, b = -10), trace = TRUE)
```

```
## 12375.66 :   15 -10
## 11678.52 :   16.15356 -12.35728
## 11664.34 :   16.44726 -12.77883
## 11664.27 :   16.46904 -12.80886
## 11664.27 :   16.47026 -12.81070
```

term	estimate	std.error	statistic	p.value
a	16.47026	0.1853400	88.86515	0
b	-12.81070	0.2445795	-52.37845	0

sigma	isConv	finTol	logLik	AIC	BIC	deviance	df.residual
2.064765	TRUE	8.6e-06	-5869.149	11744.3	11762.04	11664.27	2736



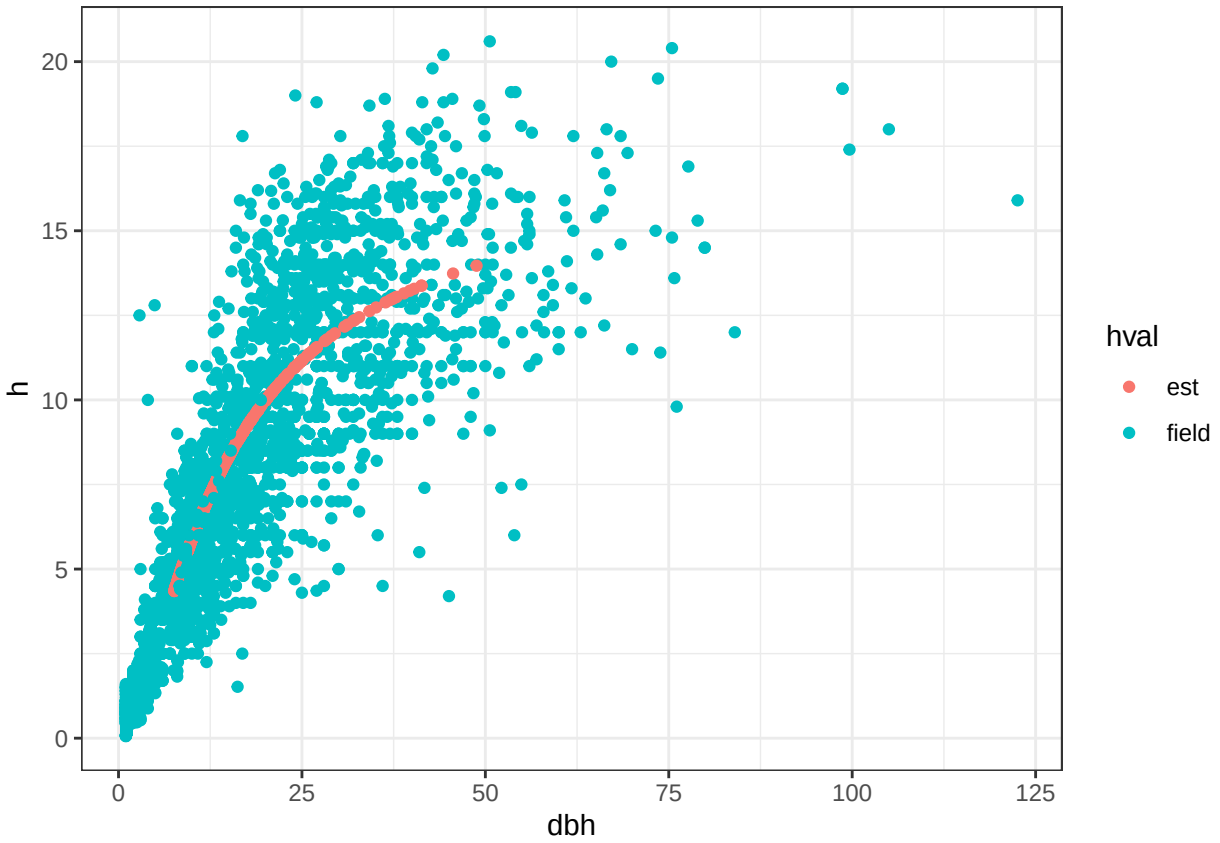
Compute the estimate values

```
tree %<>%
  mutate(h = ifelse(
    sp == "Qpyr" & hval == "est",
    predict(m, list(dbh = dbh)),
    h))
```

```
## mutate: changed 662 values (19%) of 'h' (662 fewer NA)
```

```
# (1.3 + coef(m)[1]*exp(coef(m)[2]/dbh))
```

```
## Warning: Removed 5 rows containing missing values (geom_point).
```



Export data

```
write_csv(tree, here::here("data/tree_data_full.csv"))
```

References

Adame, Patricia, Miren del Río, and Isabel Cañellas. 2008. "A Mixed Nonlinear HeightDiameter Model for Pyrenean Oak (Quercus Pyrenaica Willd.)." *Forest Ecology and Management* 256 (1-2): 88–98. https://doi.org/10.1016/j.foreco.2008.04.006.

Ruiz-Peinado, R., G. Montero, and M. Del Rio. 2012. "Biomass Models to Estimate Carbon Stocks for Hardwood Tree Species." *Forest Systems* 21 (1): 42. https://doi.org/10.5424/fs/2112211-02193.