

# JFL Intraspecific Variability Effects

Assemblage-weighted means

JAH

## Background

In this literate stastitcal document, we calculate Jan Leps *et al.*'s Intraspecific varability effects for some trait data collected in Jianfengling, Hainan Island China during the summer 2017. Above and belowground traits were collected including: leaf thickness, leaf dry mass, leaf area, leaf width, leaf height, leaf perimeter, SLA, root mass, average root diameter, number of root tips, number of root forks, root area, root length, root volume, specific root length, specific root area, specific root tip abundance, root length per volume, root tissue density, and root branchiness.

We have abundance and basal area data from a network of small plots established by Han Xu (Chinese Academy of Forestry, Guangzhou, China) - see:

- Xu et al. (2015) Journal of Applied Ecology 52:1044-1052.
- Xu et al. (2015) Journal of Ecology 103:1325-1333.

Briefly, abundances and sizes (for basal area calcuialtion) of the species on which traits were measured, were determined from plot inventory data for 164 0.0625 Ha plots established across the Jianfengling forest. 52 were in pirmary forest, while the remaining 112 were in secondary forest.

We use those basal area proporions to calculate the “intraspecific variability effect” (see Jan Leps et al. 2011, Ecography 34: 856-863), which is defined as:

*Intraspecific variability effect* = *Specific average* – *Fixed average*, where the Fixed average is a site-independent weghted trait mean (in this case independent of forest type), thus we can note mathematically:

$$Fixed\ average = \sum_{i=1}^s p_i x_i$$

, where  $p_i$  is the portion of the  $i$ th species in the community and  $x_i$  is the fixed point mean trait value. Similarly, the Specific average is the site-(or habitat, in this case Forest type)-specific weighted trait mean, given as:

$$Specific\ average = \sum_{i=1}^s p_i x_{i\_habitat}$$

The method goes futher to statisticall test the degree to which (intraspecific) trait variability interacts with species turnover, and decomposes that variation to allow for ecologically meaningful interpretaion of trait-variability, beta diversity interactions along environmental gradients.

The function used to do that (which is implemented here is `trait.flex.anova()` available in the supplemnetary material for Leps et al 2011. link here: [www.oikosoffice.lu.se/appendix](http://www.oikosoffice.lu.se/appendix) - Appendix E6904 in *Ecography*).

## Trait Flex ANOVAS

### Leaf Mass

##

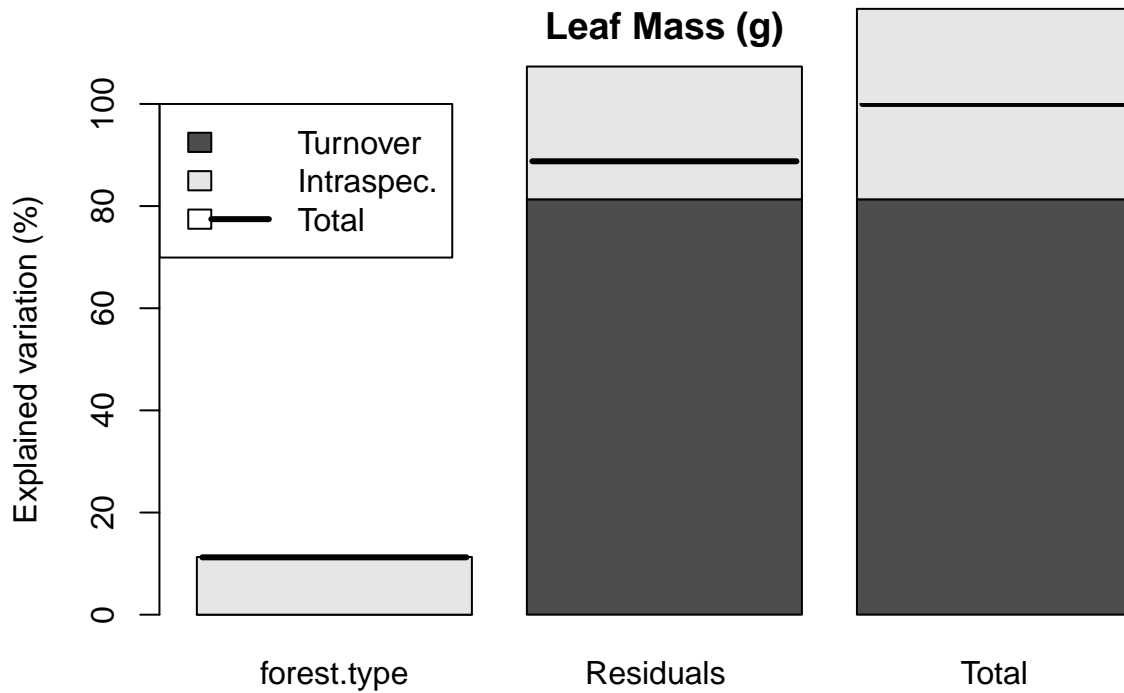
## Decomposing trait sum of squares into composition turnover

## effect, intraspecific trait variability, and their covariation:

```

##           Turnover Intraspec. Covariation   Total
## forest.type 2.1517e-05   2.1389   -0.013568  2.1254
## Residuals  1.5399e+01   4.9238   -3.512308 16.8103
## Total      1.5399e+01   7.0627   -3.525877 18.9357
##
## Relative contributions:
##           Turnover Intraspec. Covariation   Total
## forest.type 1.136e-06   0.113   -0.0007165 0.1122
## Residuals  8.132e-01   0.260   -0.1854860 0.8878
## Total      8.132e-01   0.373   -0.1862026 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec.   Total
## forest.type 0.98801 2.2881e-14 1.1598e-05

```



### Leaf Area

```

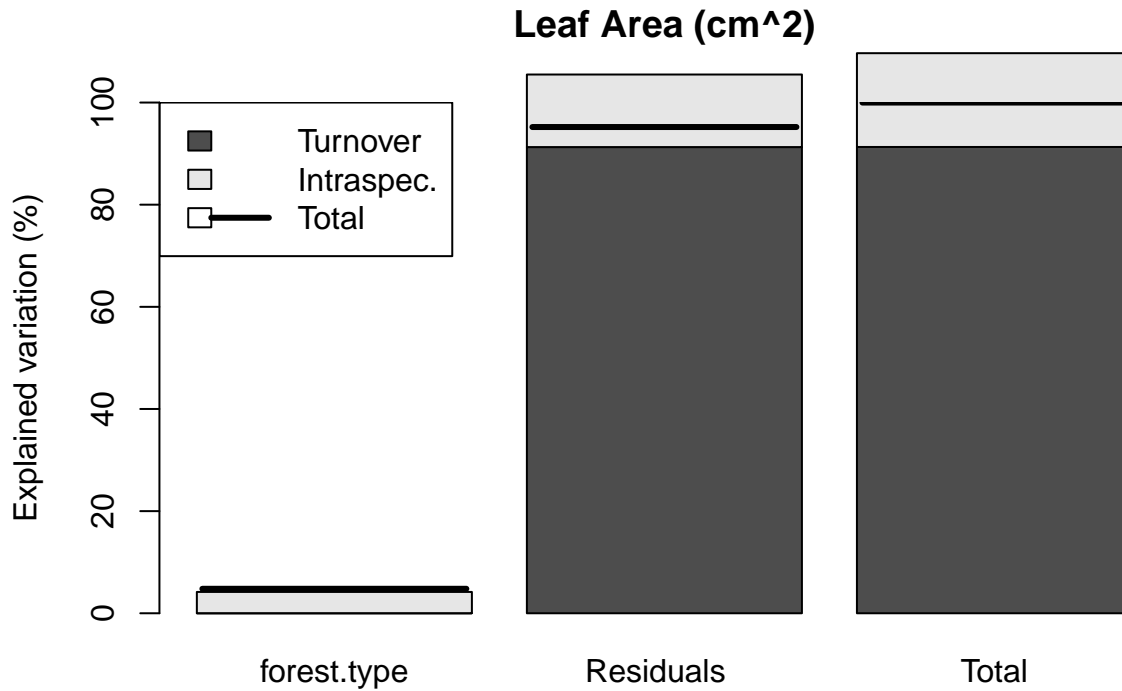
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation   Total
## forest.type  19.937   3696.9   542.98  4259.8
## Residuals  81149.233  12628.9  -9135.77  84642.4
## Total      81169.171  16325.8  -8592.79  88902.2
##

```

```

## Relative contributions:
##           Turnover Intraspec. Covariation  Total
## forest.type 0.0002243  0.04158  0.006108 0.04792
## Residuals  0.9127925  0.14205  -0.102762 0.95208
## Total      0.9130167  0.18364  -0.096654 1.00000
##
## Significance of testable effects:
##           Turnover Intraspec.  Total
## forest.type 0.84212 1.1972e-10 0.004862

```



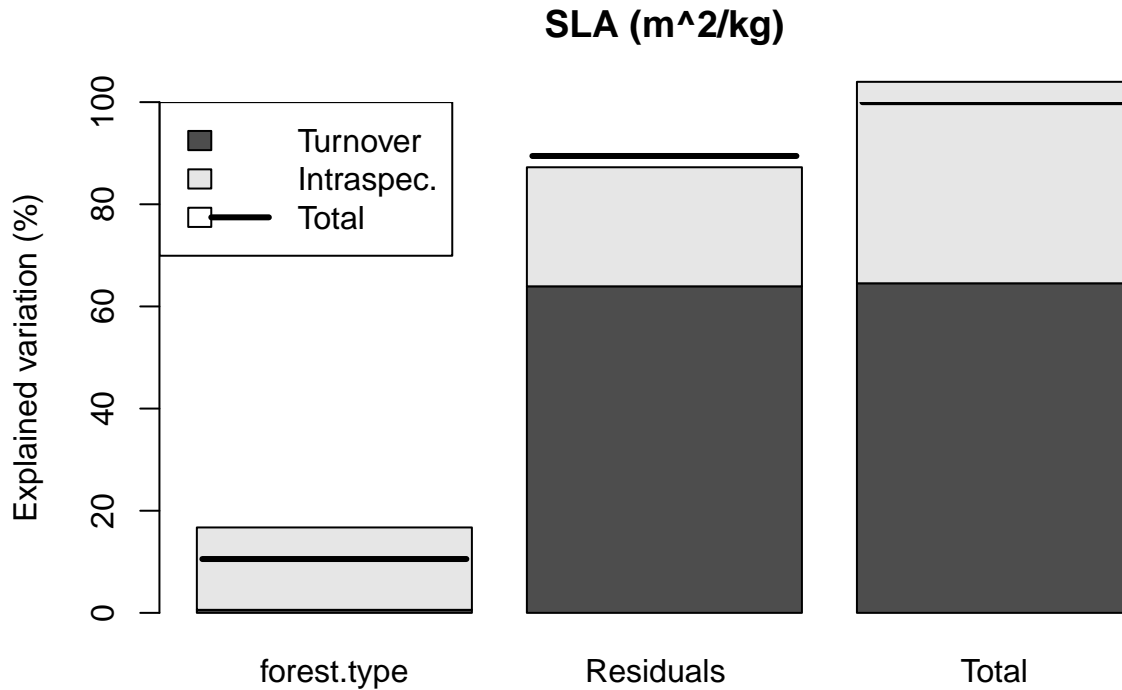
## SLA

```

##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation  Total
## forest.type  3.4563  94.118  -36.072  61.502
## Residuals   372.9233  135.971  12.875  521.769
## Total       376.3796  230.088  -23.198  583.270
##
## Relative contributions:
##           Turnover Intraspec. Covariation  Total
## forest.type 0.005926  0.1614  -0.06184 0.1054
## Residuals  0.639366  0.2331  0.02207 0.8946
## Total     0.645292  0.3945  -0.03977 1.0000

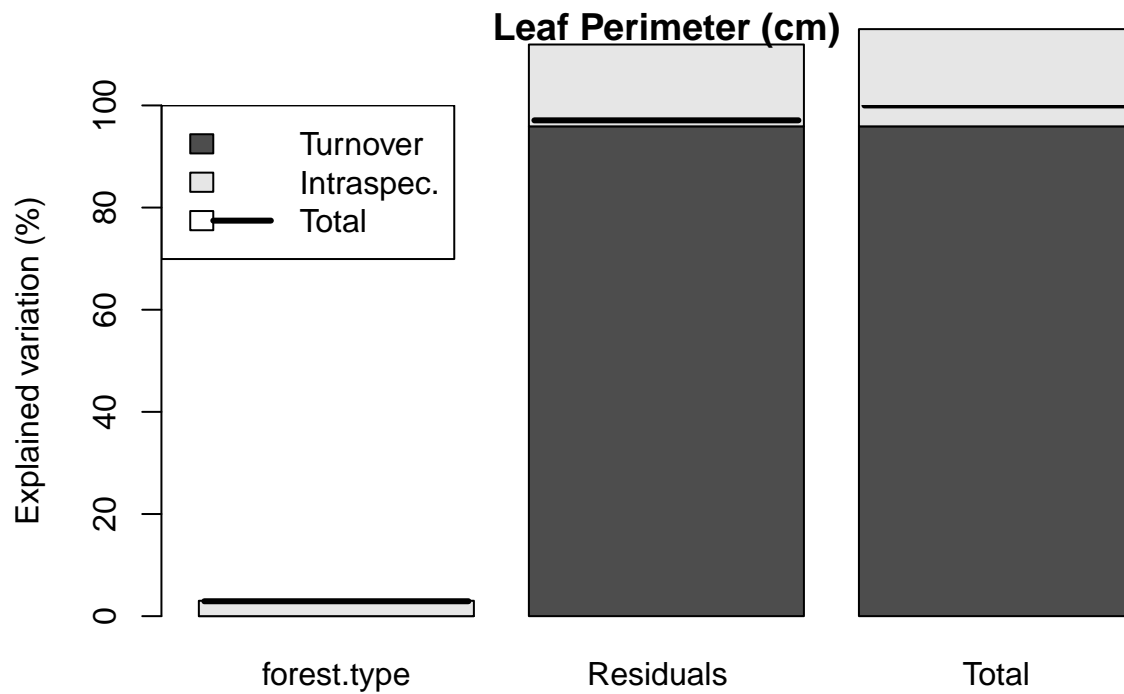
```

```
##
## Significance of testable effects:
##           Turnover Intraspec.      Total
## forest.type  0.22223 3.0372e-20 2.2137e-05
```



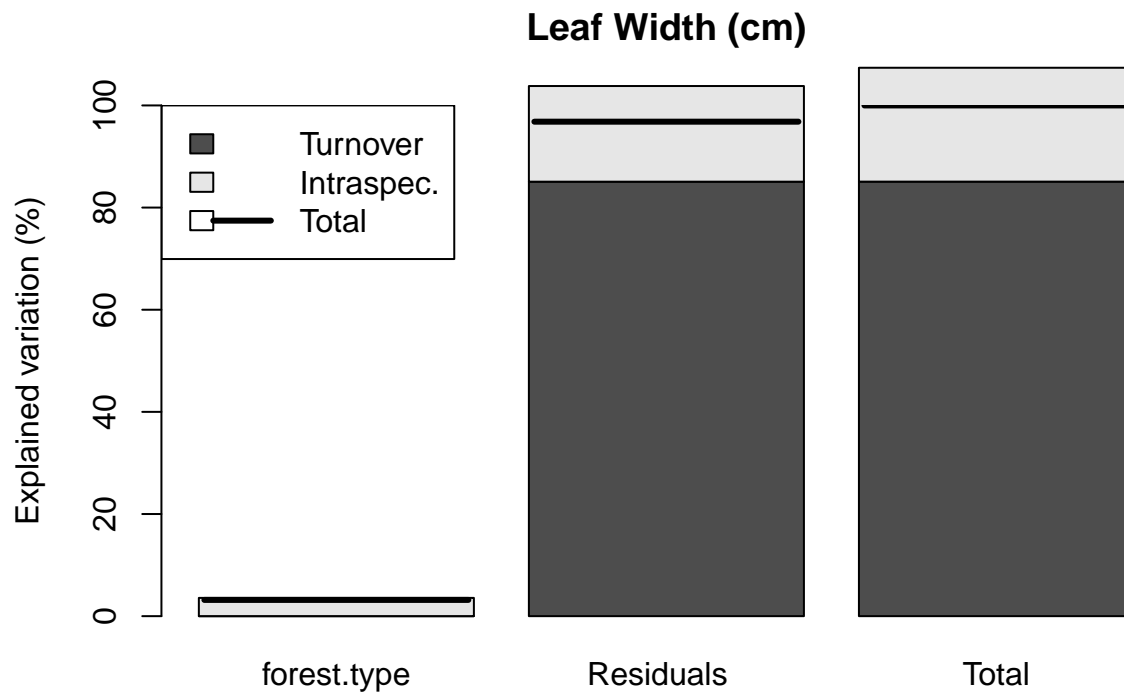
### Leaf Perimeter

```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation      Total
## forest.type 1.6166e+00    6358.3    -202.77    6157.1
## Residuals   2.0246e+05    33842.2   -31340.68 204960.2
## Total       2.0246e+05    40200.5   -31543.45 211117.3
##
## Relative contributions:
##           Turnover Intraspec. Covariation      Total
## forest.type 7.658e-06    0.03012   -0.0009605 0.02916
## Residuals   9.590e-01    0.16030   -0.1484515 0.97084
## Total       9.590e-01    0.19042   -0.1494119 1.00000
##
## Significance of testable effects:
##           Turnover Intraspec.      Total
## forest.type  0.97135 1.3405e-07 0.028789
```



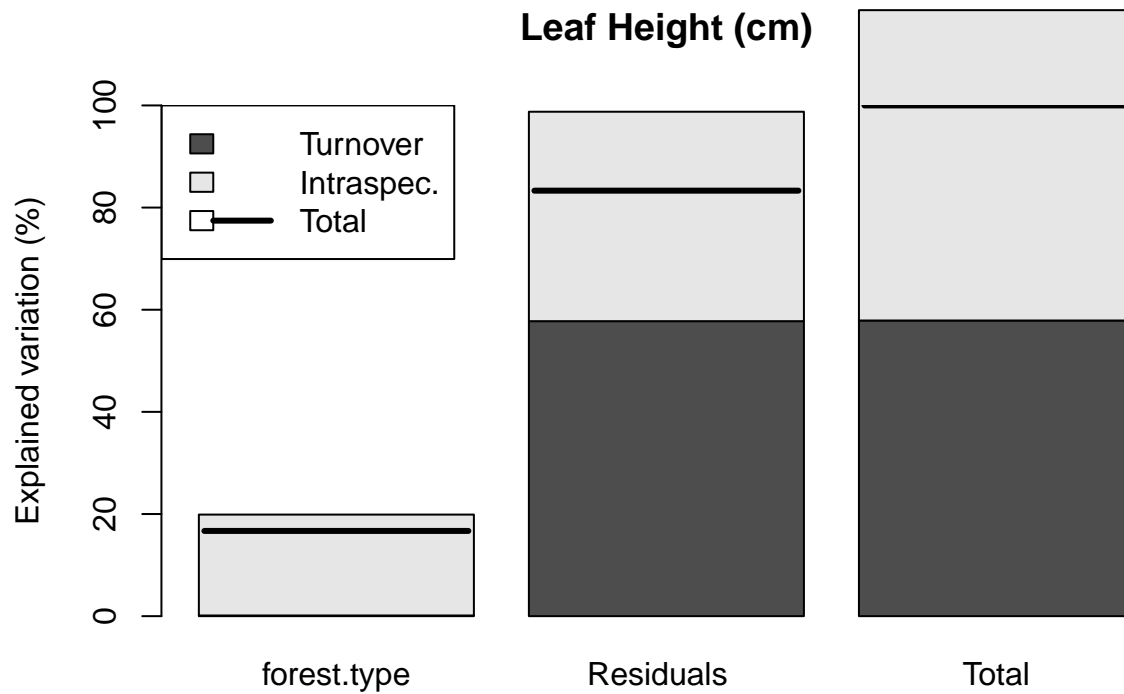
### Leaf Width

```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation   Total
## forest.type  0.19403    62.12    -6.9435   55.371
## Residuals   1481.23115   326.08   -121.4866 1685.821
## Total       1481.42518   388.20   -128.4302 1741.191
##
## Relative contributions:
##           Turnover Intraspec. Covariation   Total
## forest.type 0.0001114    0.03568   -0.003988 0.0318
## Residuals  0.8506998    0.18727   -0.069772 0.9682
## Total      0.8508113    0.22295   -0.073760 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec.   Total
## forest.type 0.88436 1.1147e-07 0.022338
```



### Leaf Height

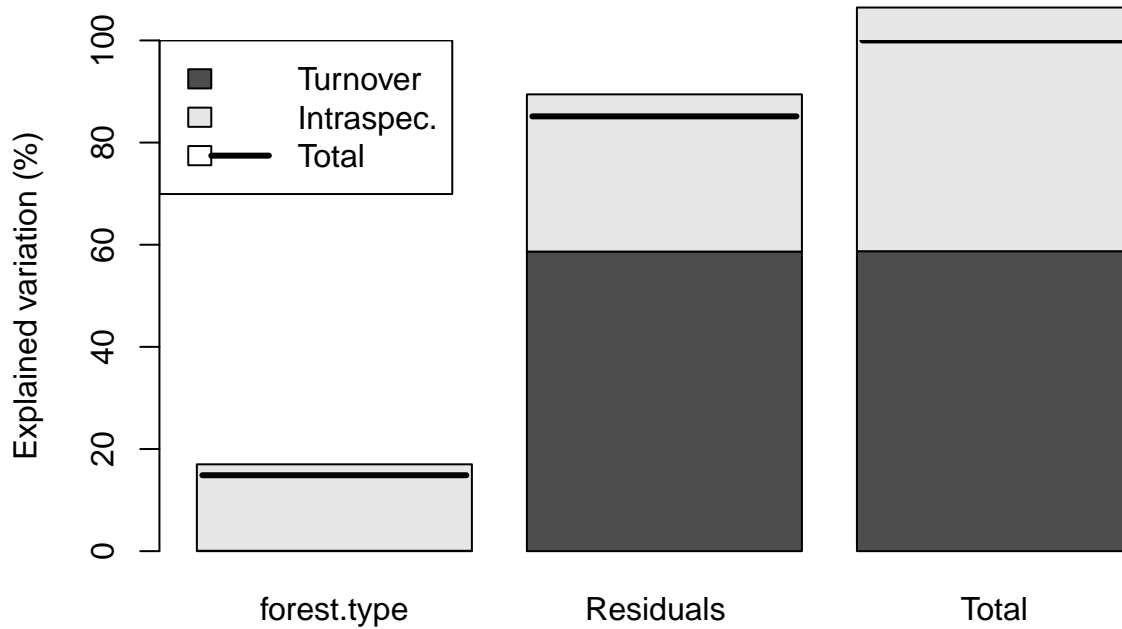
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation   Total
## forest.type  0.57013    87.025    -14.088  73.508
## Residuals   254.40949   180.629    -68.093 366.945
## Total       254.97961   267.654    -82.181 440.452
##
## Relative contributions:
##           Turnover Intraspec. Covariation   Total
## forest.type 0.001294    0.1976    -0.03198 0.1669
## Residuals  0.577609    0.4101    -0.15460 0.8331
## Total     0.578904    0.6077    -0.18658 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec.   Total
## forest.type 0.54767 1.5899e-15 5.6203e-08
```



### Leaf Thickness

```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation   Total
## forest.type 8.0338e-05  0.020167 -0.0025457 0.017702
## Residuals   6.9865e-02  0.036661 -0.0051287 0.101398
## Total       6.9946e-02  0.056828 -0.0076744 0.119099
##
## Relative contributions:
##           Turnover Intraspec. Covariation   Total
## forest.type 0.0006745   0.1693   -0.02137 0.1486
## Residuals   0.5866146   0.3078   -0.04306 0.8514
## Total       0.5872891   0.4771   -0.06444 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec.   Total
## forest.type  0.6666 3.9616e-17 3.4362e-07
```

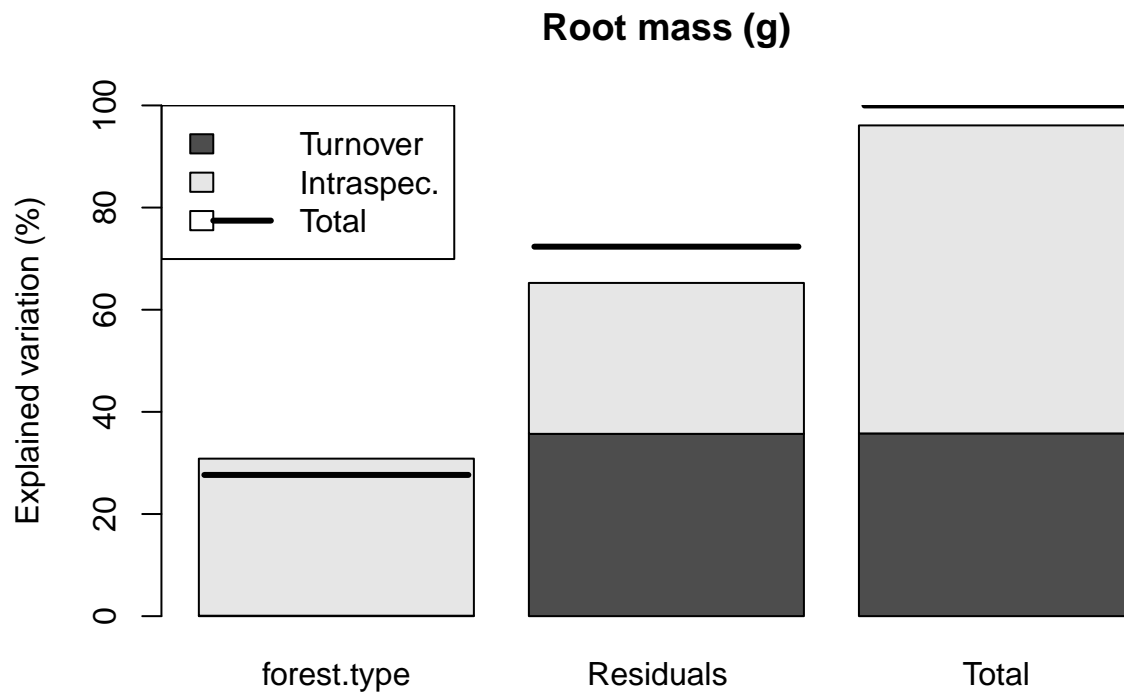
## Leaf Thickness (mm)



## Root Mass

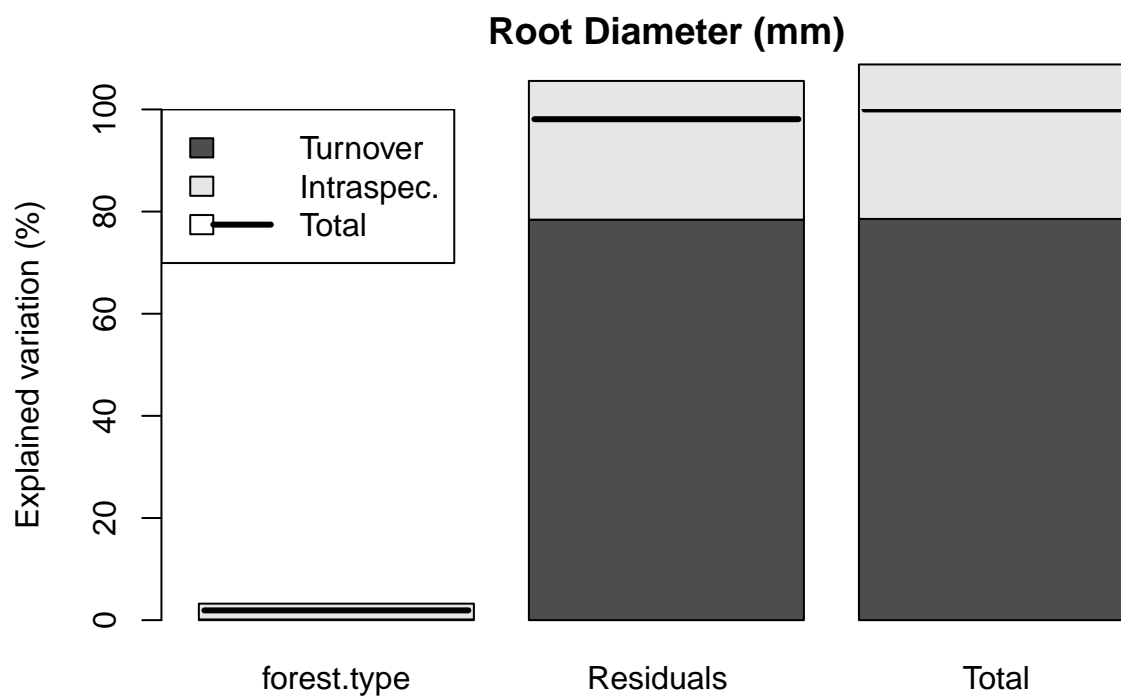
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation  Total
## forest.type 0.00096802   0.36055   -0.037364 0.32415
## Residuals   0.41840428   0.34641    0.083230 0.84805
## Total       0.41937230   0.70696    0.045866 1.17220
##
## Relative contributions:
##           Turnover Intraspec. Covariation  Total
## forest.type 0.0008258    0.3076    -0.03188 0.2765
## Residuals   0.3569403    0.2955     0.07100 0.7235
## Total       0.3577661    0.6031     0.03913 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec.  Total
## forest.type 0.54126 7.0217e-27 4.8079e-13
```





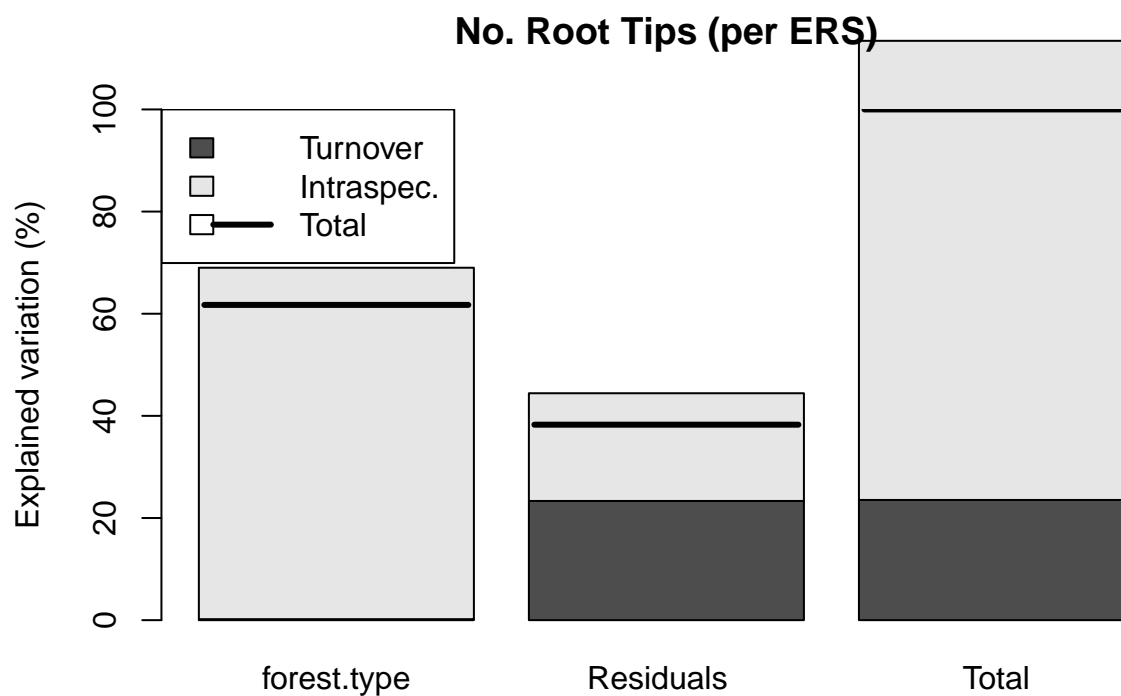
### Root Avg Diameter

```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation   Total
## forest.type 0.0030078  0.065729  -0.028121 0.040615
## Residuals   1.6687548  0.577961  -0.159367 2.087349
## Total       1.6717627  0.643690  -0.187489 2.127964
##
## Relative contributions:
##           Turnover Intraspec. Covariation   Total
## forest.type 0.001413   0.03089   -0.01322 0.01909
## Residuals   0.784203   0.27160   -0.07489 0.98091
## Total       0.785616   0.30249   -0.08811 1.00000
##
## Significance of testable effects:
##           Turnover Intraspec.   Total
## forest.type 0.58969  3.035e-05 0.077704
```



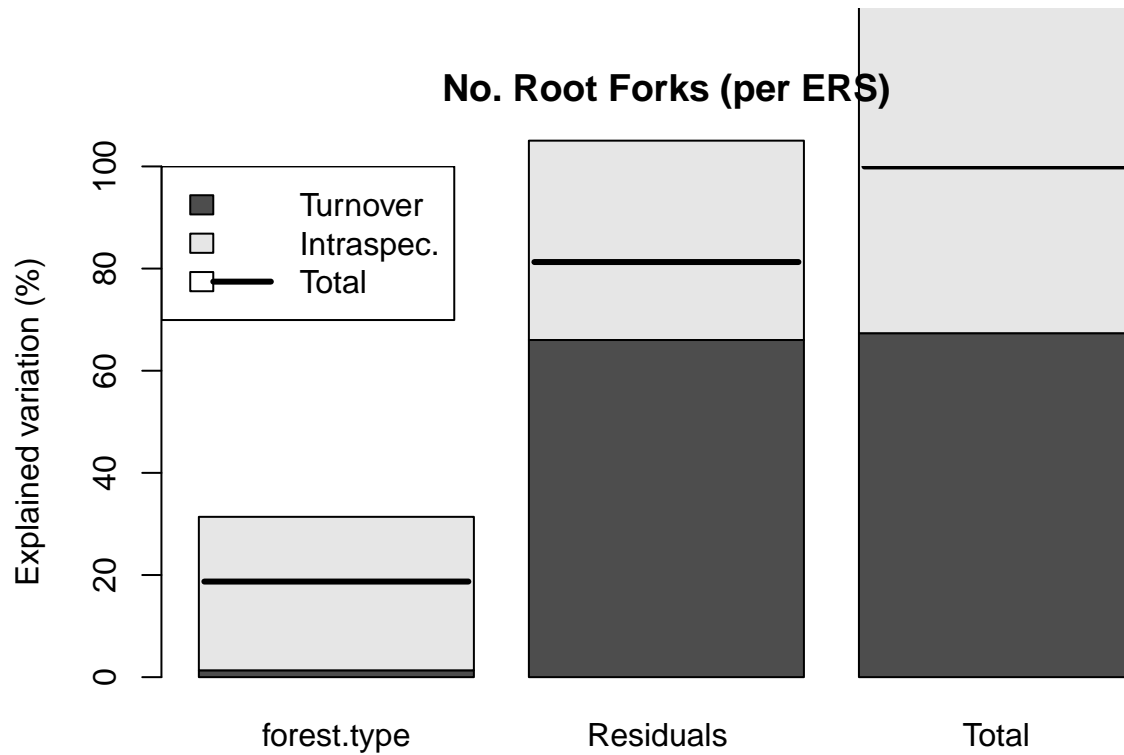
### Number of Root Tips

```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation Total
## forest.type   948.09    339022    -35857 304114
## Residuals    114996.21    103893    -30342 188547
## Total        115944.30    442915    -66199 492660
##
## Relative contributions:
##           Turnover Intraspec. Covariation Total
## forest.type 0.001924    0.6881    -0.07278 0.6173
## Residuals   0.233419    0.2109    -0.06159 0.3827
## Total       0.235343    0.8990    -0.13437 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec. Total
## forest.type 0.24951 7.0026e-53 1.2948e-35
```



### Number of Root Forks

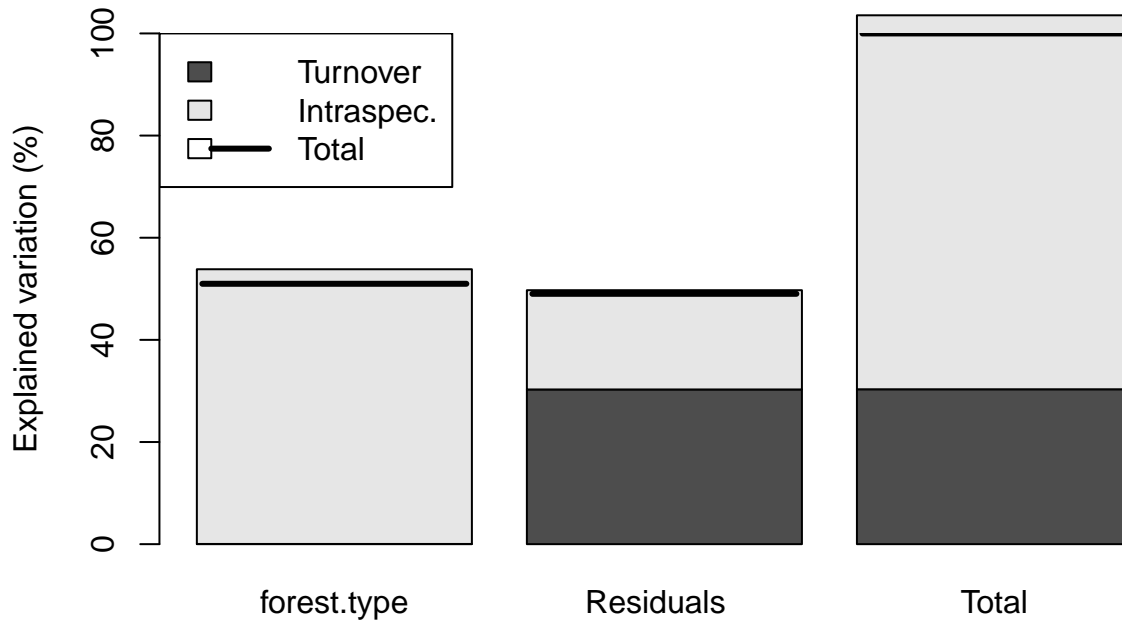
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation Total
## forest.type  8659.2    194912    -82166 121406
## Residuals   428109.7    253159    -154146 527123
## Total       436768.9    448072    -236311 648529
##
## Relative contributions:
##           Turnover Intraspec. Covariation Total
## forest.type  0.01335    0.3005    -0.1267 0.1872
## Residuals   0.66012    0.3904    -0.2377 0.8128
## Total       0.67348    0.6909    -0.3644 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec. Total
## forest.type 0.072122 7.7566e-22 7.2131e-09
```



### Root Area

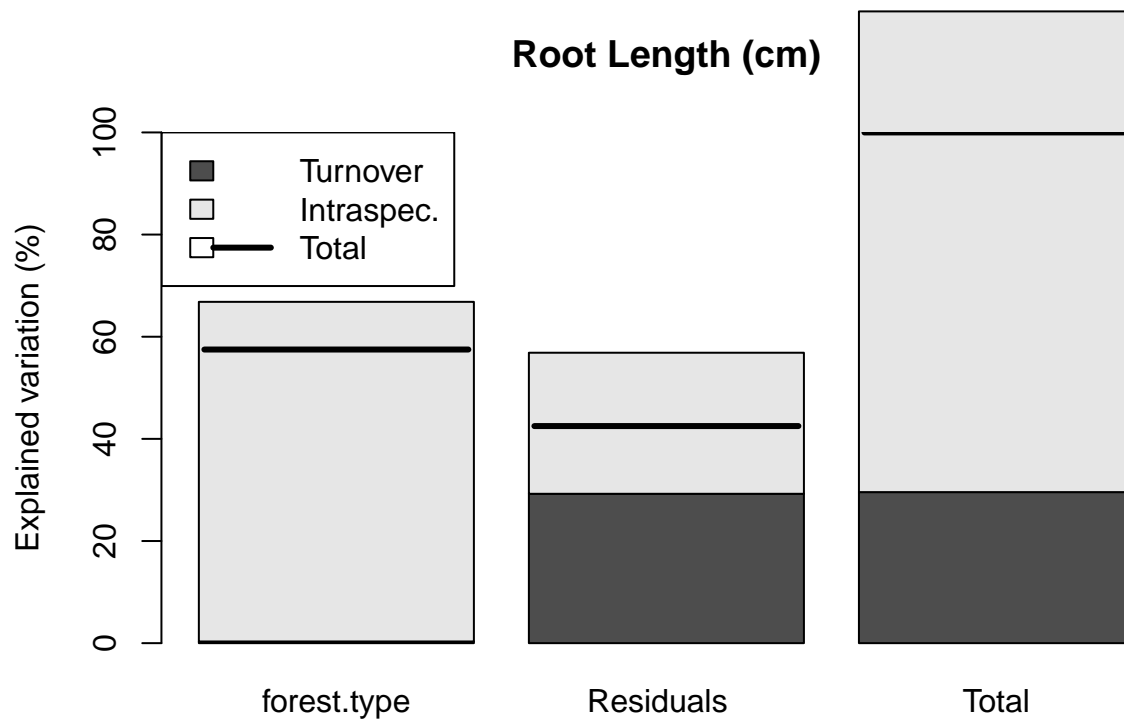
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation Total
## forest.type  1.2226   1746.81    -92.427 1655.6
## Residuals   983.5863    631.11    -22.827 1591.9
## Total       984.8089   2377.92   -115.254 3247.5
##
## Relative contributions:
##           Turnover Intraspec. Covariation Total
## forest.type 0.0003765    0.5379  -0.028461 0.5098
## Residuals  0.3028771    0.1943  -0.007029 0.4902
## Total      0.3032536    0.7322  -0.035490 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec. Total
## forest.type 0.65422 1.5813e-48 7.237e-27
```

## Root Area (cm<sup>2</sup>)



## Root Length

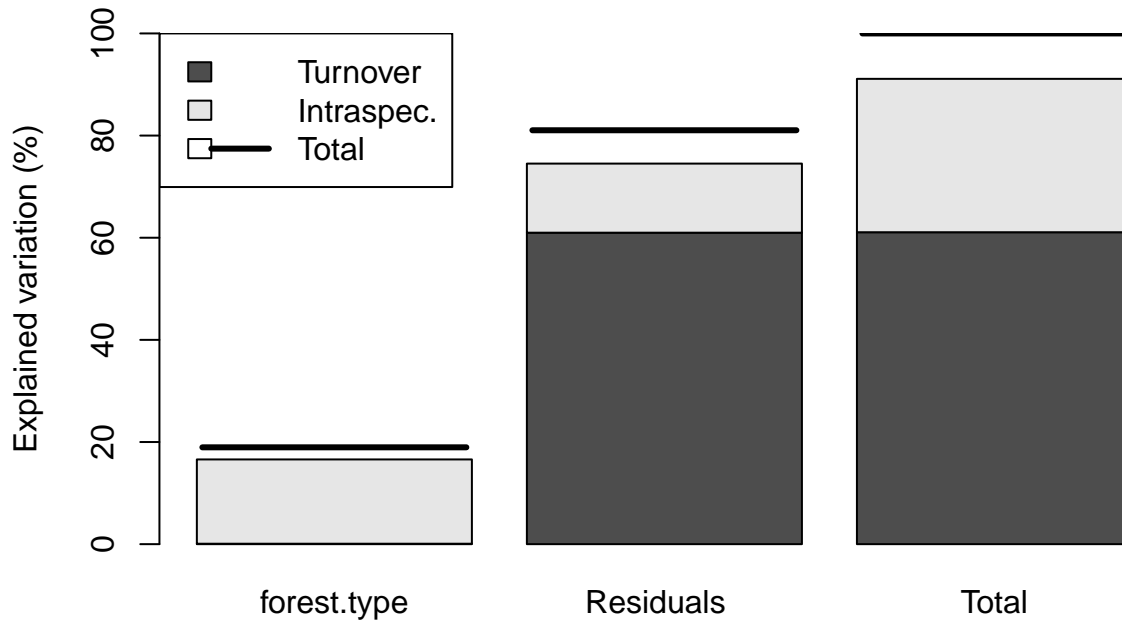
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation Total
## forest.type   198.6     40316     -5659.3 34856
## Residuals    17729.3     16747     -8706.6 25769
## Total        17927.9     57063     -14365.9 60625
##
## Relative contributions:
##           Turnover Intraspec. Covariation Total
## forest.type 0.003276     0.6650     -0.09335 0.5749
## Residuals   0.292443     0.2762     -0.14361 0.4251
## Total       0.295719     0.9412     -0.23696 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec. Total
## forest.type 0.17983 5.5479e-45 6.5956e-32
```



### Root Volume

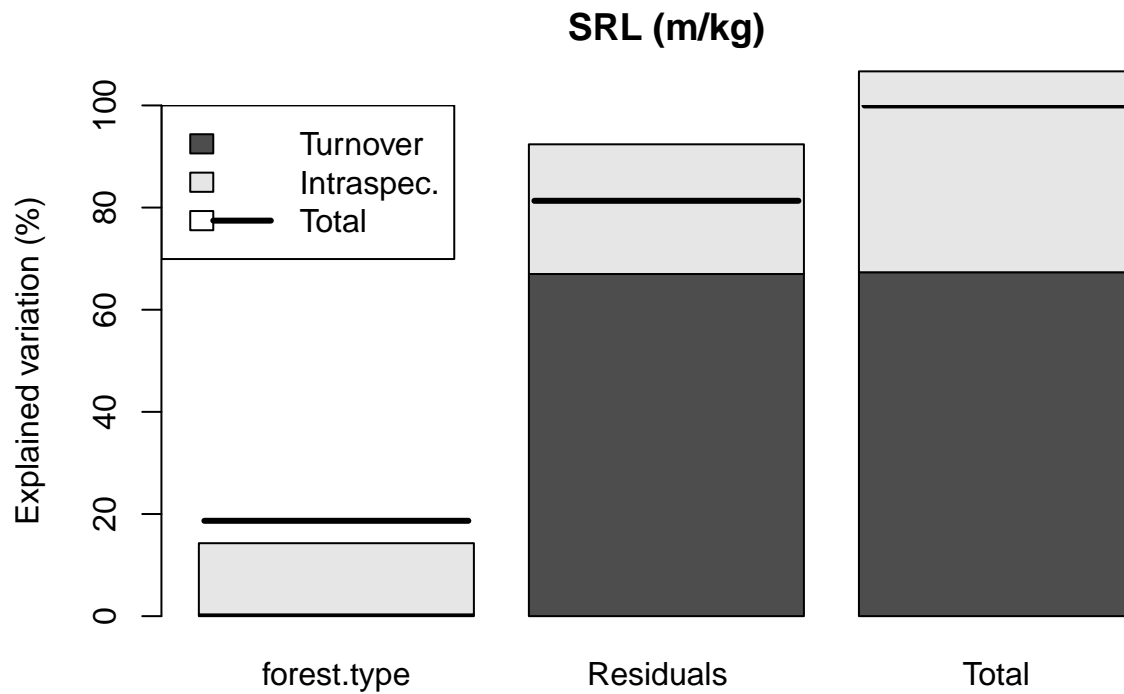
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation  Total
## forest.type 0.003203   0.62339   0.089369 0.71596
## Residuals   2.303241   0.51094   0.246439 3.06062
## Total       2.306444   1.13433   0.335808 3.77658
##
## Relative contributions:
##           Turnover Intraspec. Covariation  Total
## forest.type 0.0008481   0.1651   0.02366 0.1896
## Residuals   0.6098750   0.1353   0.06525 0.8104
## Total       0.6107231   0.3004   0.08892 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec.  Total
## forest.type 0.63568 7.3841e-30 5.6557e-09
```

## Root Volume (cm<sup>3</sup>)



## SRL

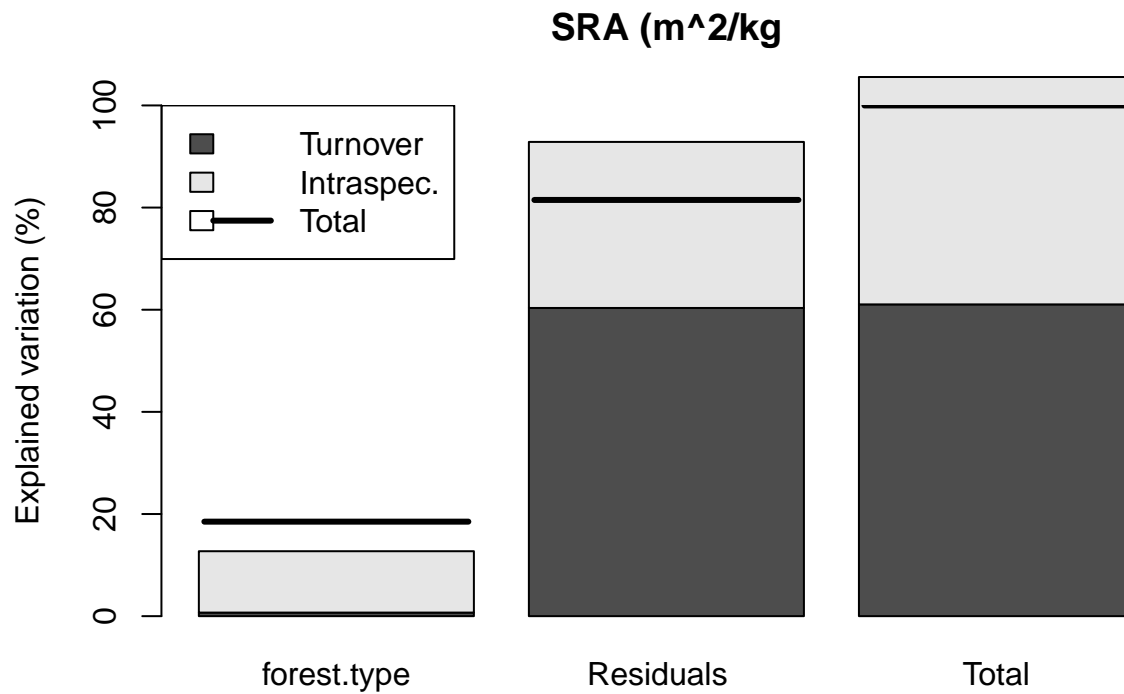
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##      Turnover Intraspec. Covariation  Total
## forest.type   81.328    3285.6      1033.9  4400.8
## Residuals   15787.988    5985.7     -2606.2 19167.5
## Total       15869.316    9271.3     -1572.4 23568.3
##
## Relative contributions:
##      Turnover Intraspec. Covariation  Total
## forest.type 0.003451    0.1394    0.04387 0.1867
## Residuals  0.669883    0.2540   -0.11058 0.8133
## Total     0.673334    0.3934   -0.06671 1.0000
##
## Significance of testable effects:
##      Turnover Intraspec.  Total
## forest.type 0.36233 4.2147e-17 7.572e-09
```



## SRA

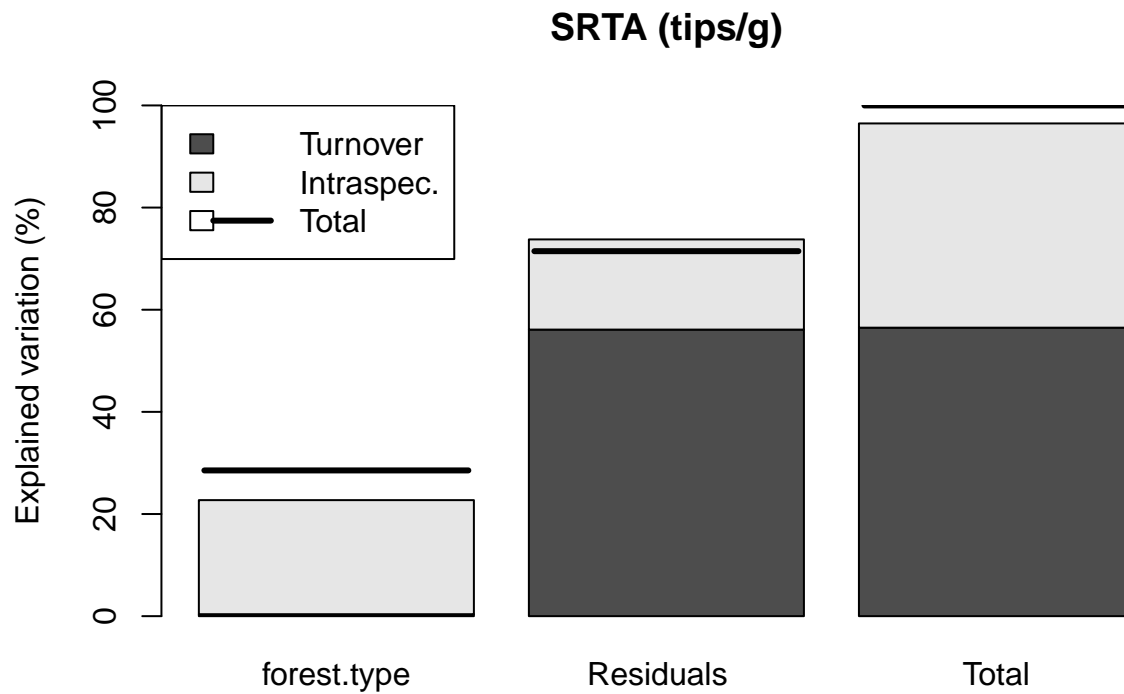
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation Total
## forest.type  4.2499    73.129    35.258 112.64
## Residuals   367.3441   197.914   -69.147 496.11
## Total       371.5940   271.043   -33.889 608.75
##
## Relative contributions:
##           Turnover Intraspec. Covariation Total
## forest.type 0.006981    0.1201    0.05792 0.185
## Residuals  0.603442    0.3251   -0.11359 0.815
## Total     0.610423    0.4452   -0.05567 1.000
##
## Significance of testable effects:
##           Turnover Intraspec. Total
## forest.type 0.17289 1.0293e-12 9.0016e-09
```





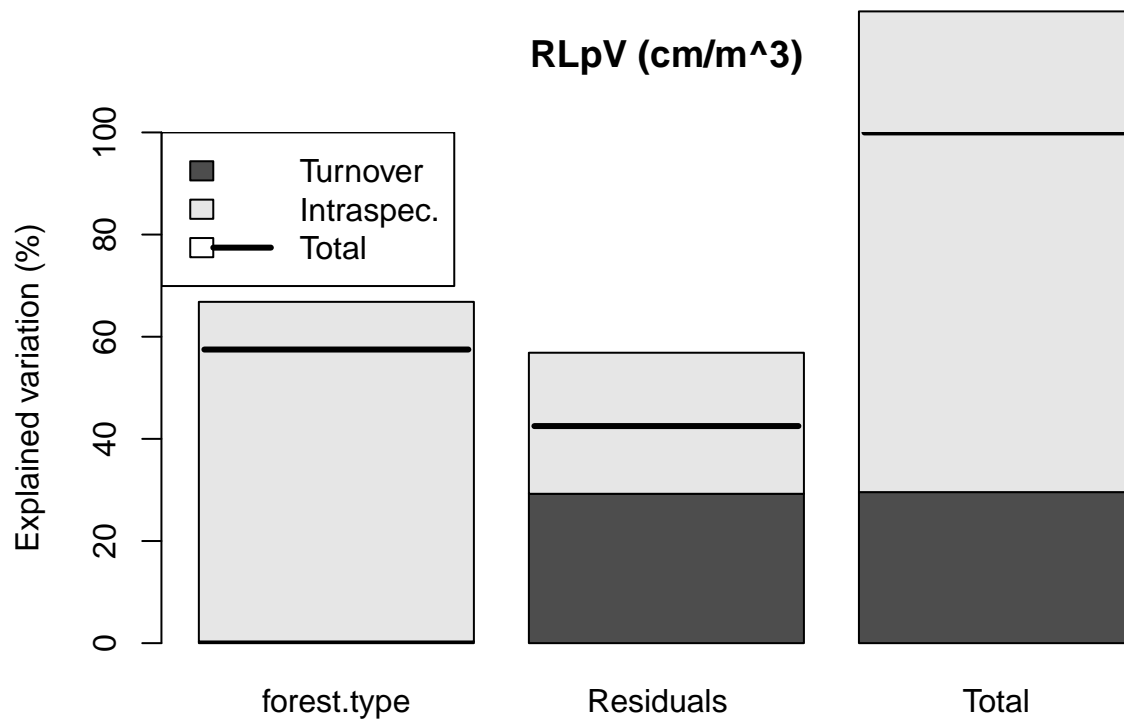
### SR Tip Abundance

```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation   Total
## forest.type    63932   3763684     981064  4808680
## Residuals     9454703   2975285    -387383 12042604
## Total         9518635   6738968     593681 16851285
##
## Relative contributions:
##           Turnover Intraspec. Covariation   Total
## forest.type  0.003794    0.2233    0.05822 0.2854
## Residuals   0.561067    0.1766   -0.02299 0.7146
## Total       0.564861    0.3999    0.03523 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec.   Total
## forest.type  0.29683 1.4477e-30 1.7519e-13
```



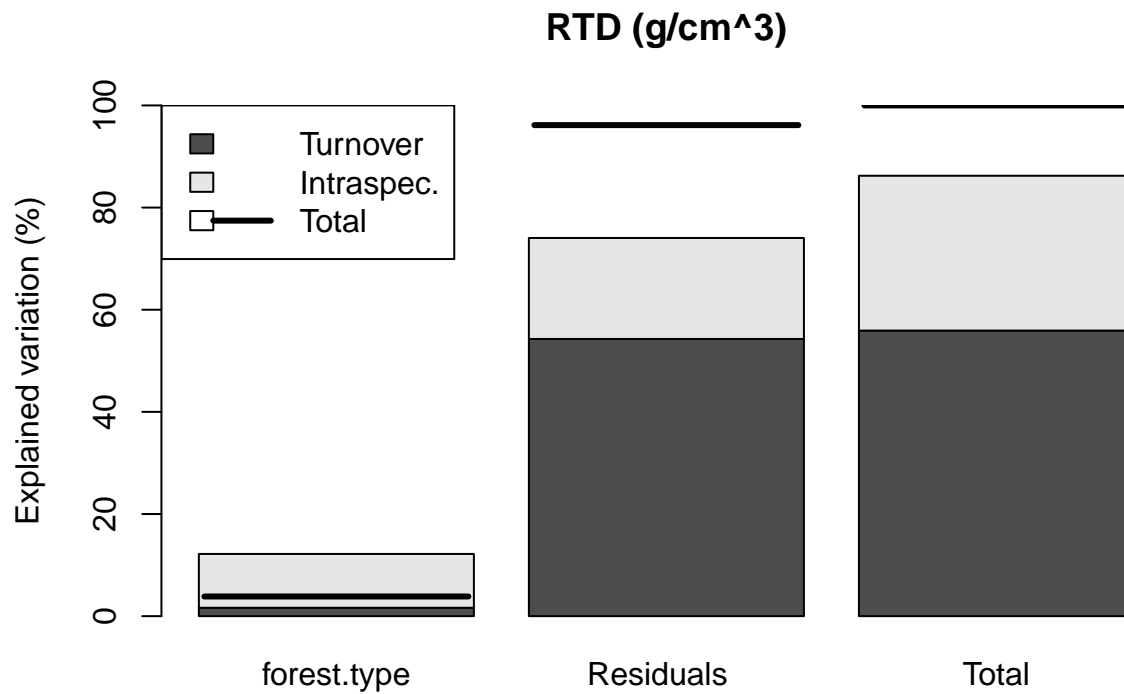
### Root Length Per Volume

```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation Total
## forest.type   198.6     40316     -5659.3 34856
## Residuals    17729.3     16747     -8706.6 25769
## Total        17927.9     57063     -14365.9 60625
##
## Relative contributions:
##           Turnover Intraspec. Covariation Total
## forest.type 0.003276     0.6650     -0.09335 0.5749
## Residuals   0.292443     0.2762     -0.14361 0.4251
## Total       0.295719     0.9412     -0.23696 1.0000
##
## Significance of testable effects:
##           Turnover Intraspec. Total
## forest.type 0.17983 5.5479e-45 6.5956e-32
```



### Root Tissue Density

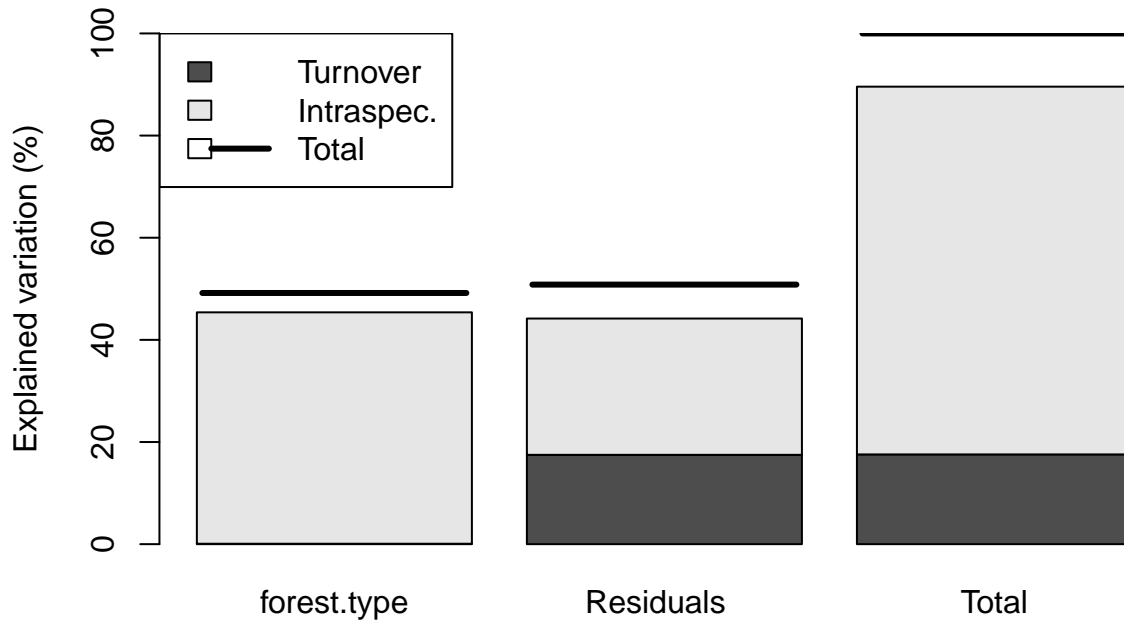
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation   Total
## forest.type  0.01585   0.10143   -0.08019  0.037088
## Residuals    0.52233   0.19034    0.21271  0.925385
## Total        0.53818   0.29177    0.13252  0.962473
##
## Relative contributions:
##           Turnover Intraspec. Covariation   Total
## forest.type  0.01647    0.1054   -0.08332  0.03853
## Residuals    0.54270    0.1978    0.22101  0.96147
## Total        0.55917    0.3031    0.13769  1.00000
##
## Significance of testable effects:
##           Turnover Intraspec.   Total
## forest.type 0.028005 9.8843e-17 0.011762
```



### Root Branchiness

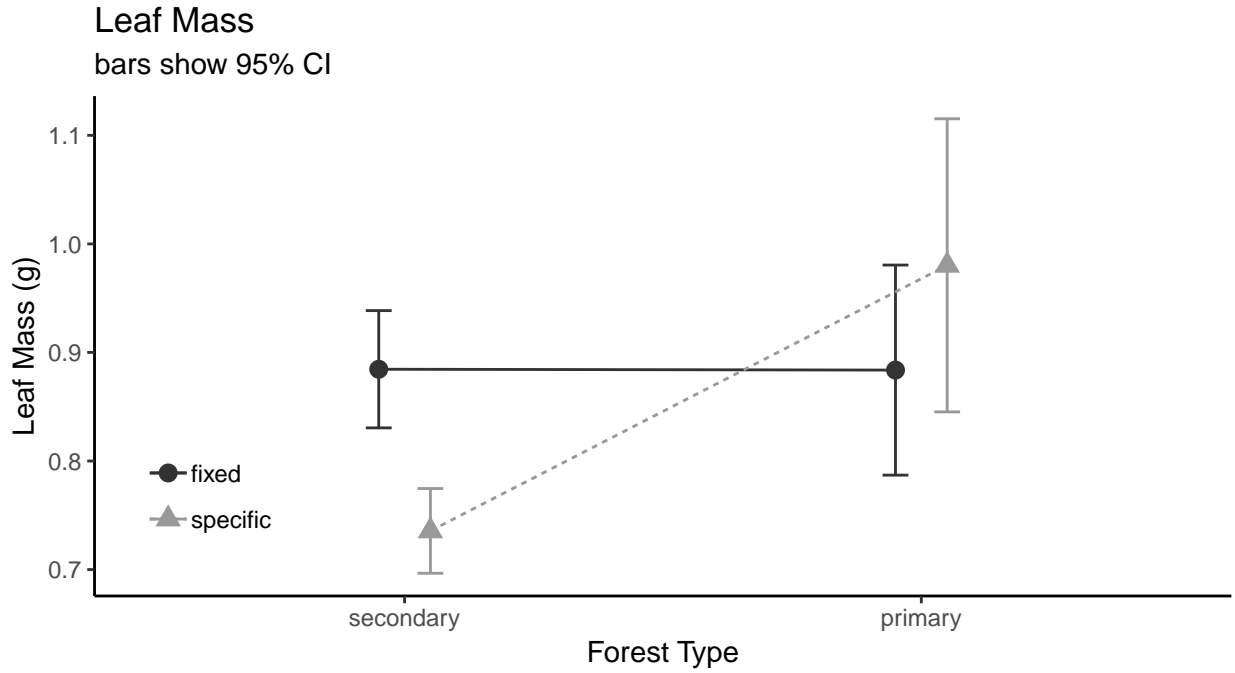
```
##
## Decomposing trait sum of squares into composition turnover
## effect, intraspecific trait variability, and their covariation:
##           Turnover Intraspec. Covariation   Total
## forest.type 0.0089921    5.1527    0.43050  5.5922
## Residuals   1.9887151    3.0355    0.75499  5.7792
## Total       1.9977072    8.1882    1.18549 11.3714
##
## Relative contributions:
##           Turnover Intraspec. Covariation   Total
## forest.type 0.0007908    0.4531    0.03786  0.4918
## Residuals   0.1748878    0.2669    0.06639  0.5082
## Total       0.1756785    0.7201    0.10425  1.0000
##
## Significance of testable effects:
##           Turnover Intraspec.   Total
## forest.type 0.39334  9.72e-37 1.3746e-25
```

### Root Branchiness (tips/length

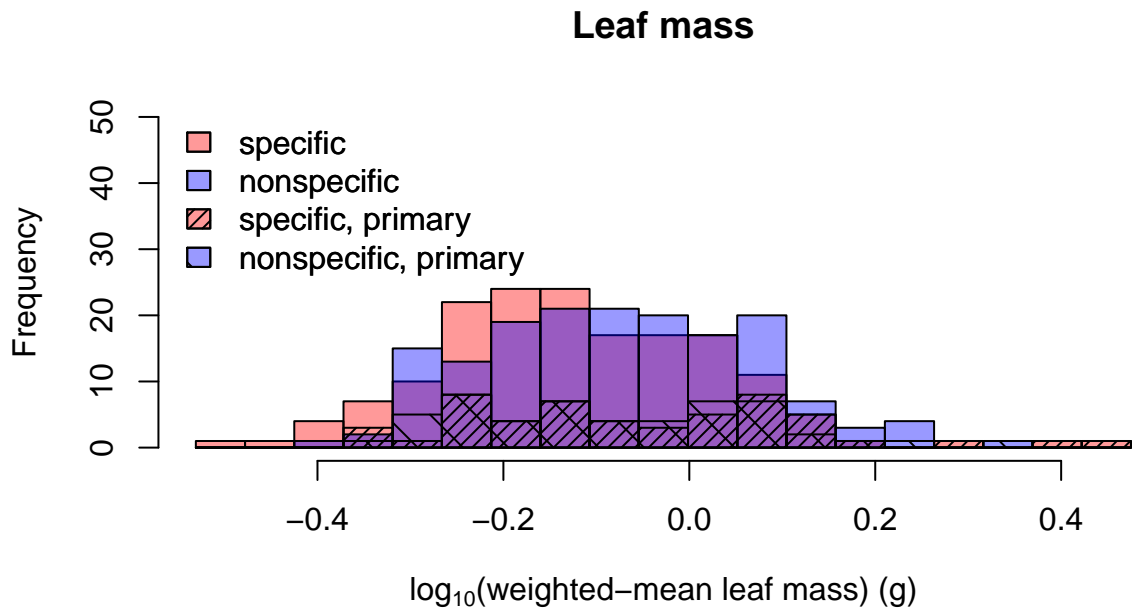


# PLOTTING weighted averages

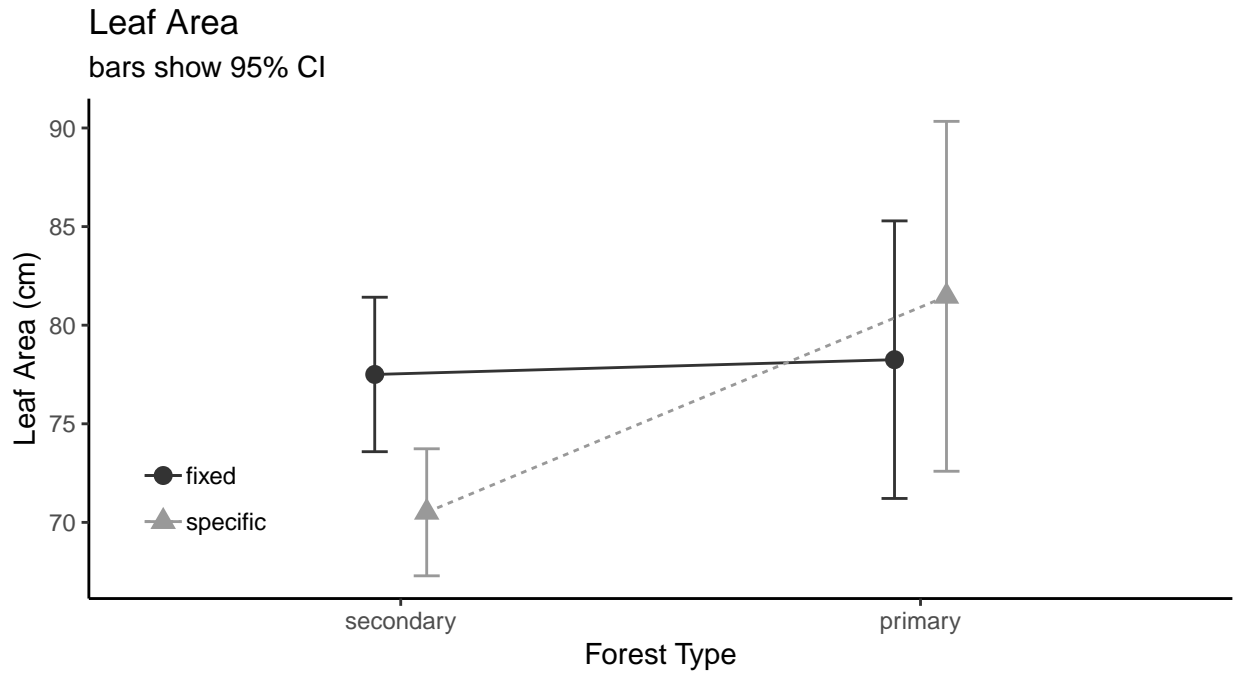
## Leaf Mass



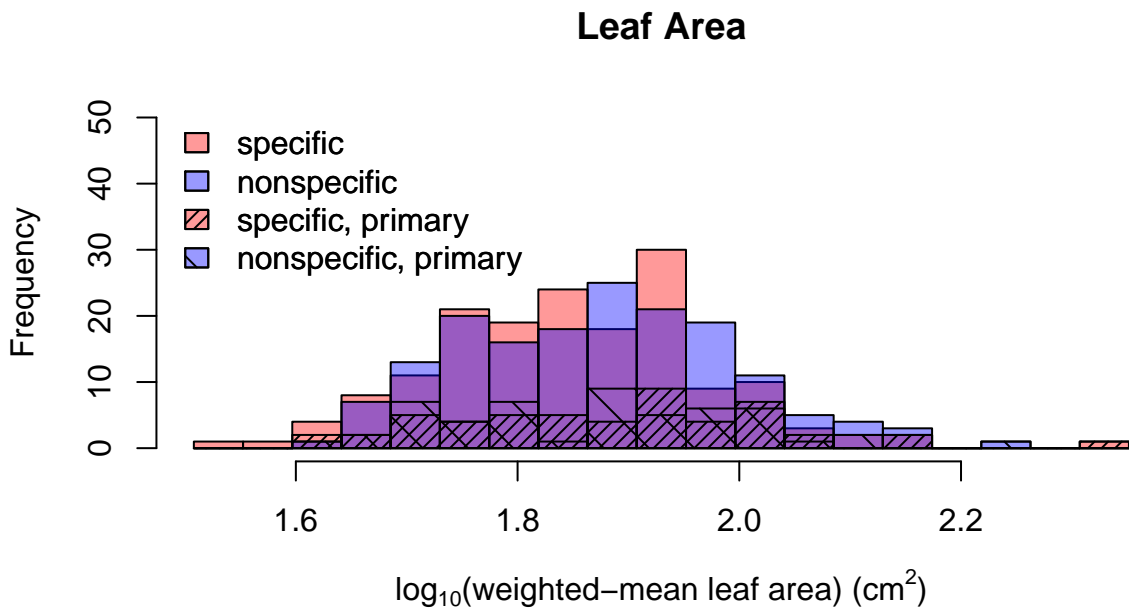
## histogram



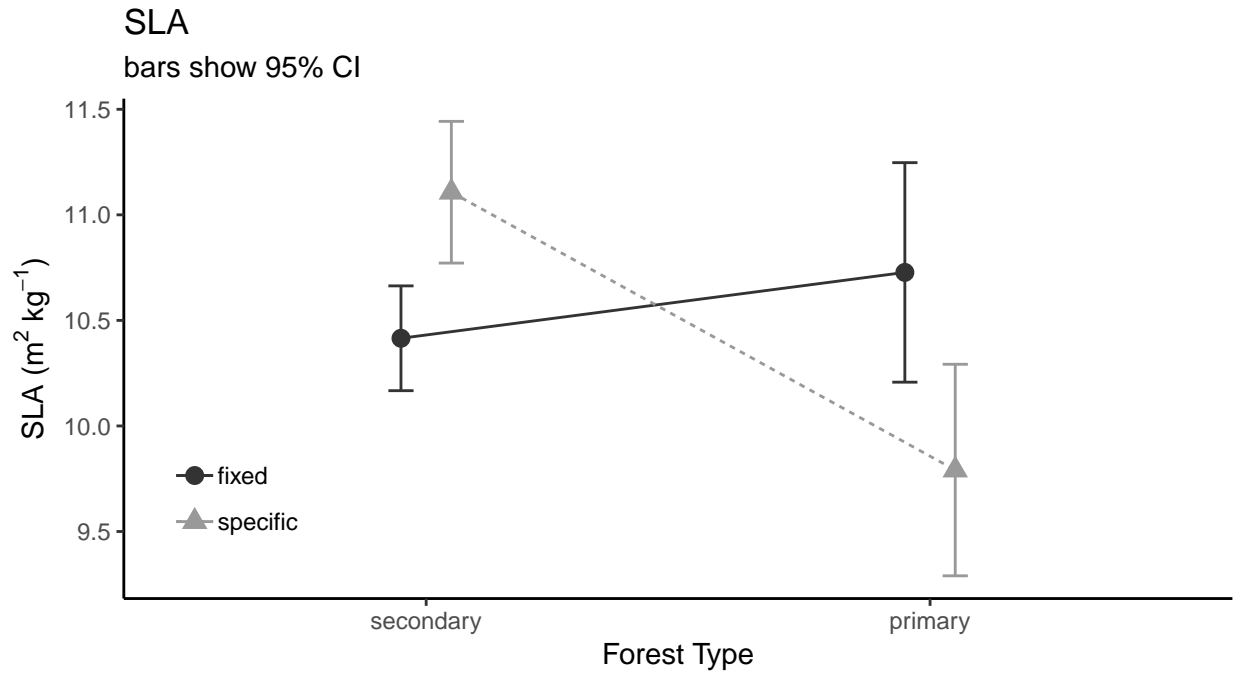
## Leaf Area



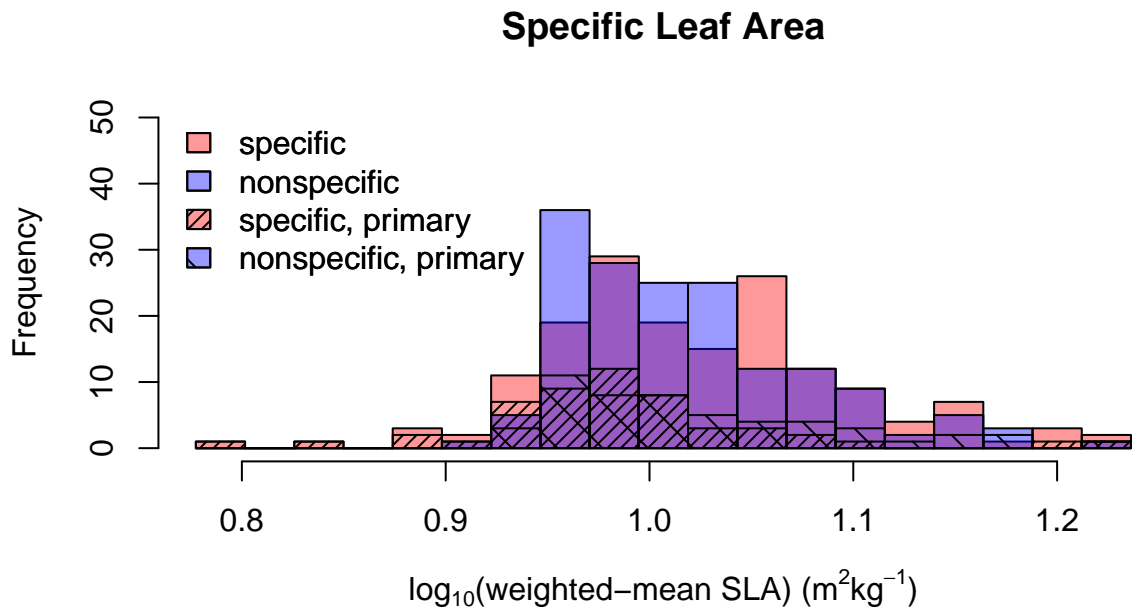
## histogram



## SLA

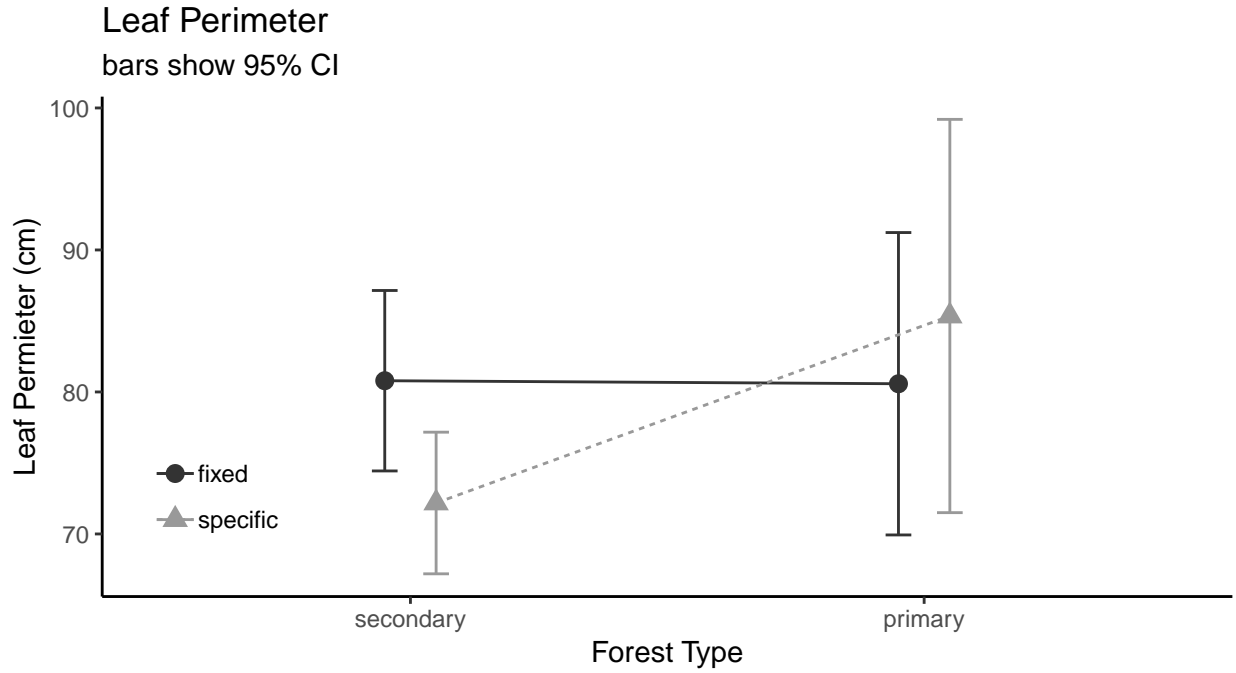


## histogram

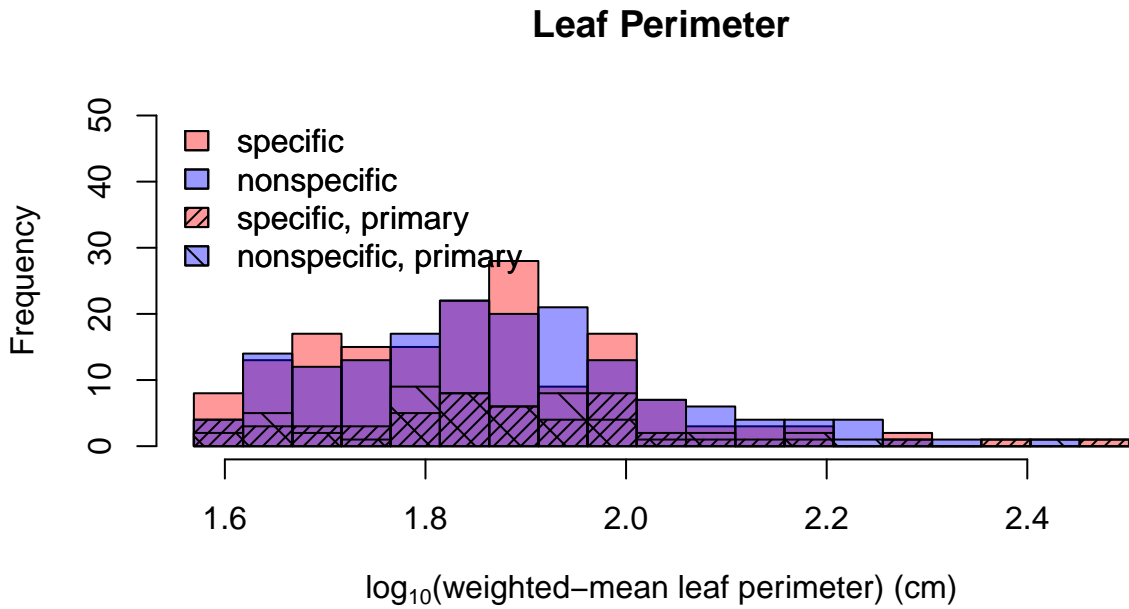




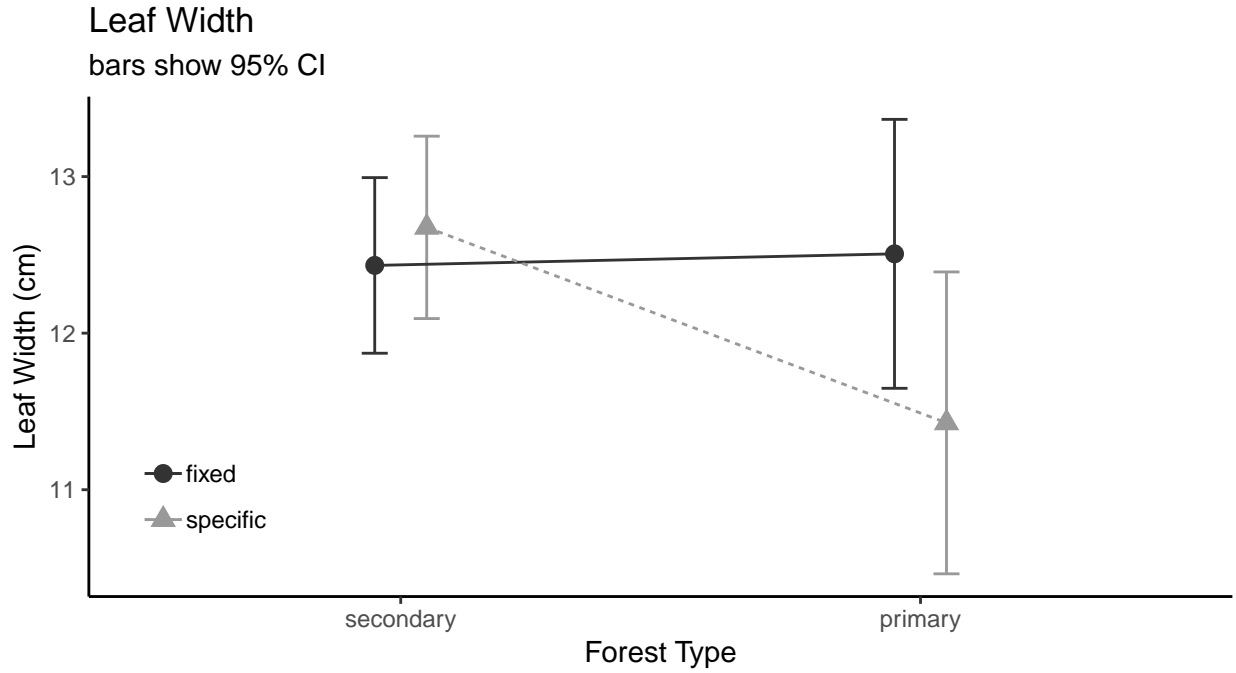
## Leaf Perimeter



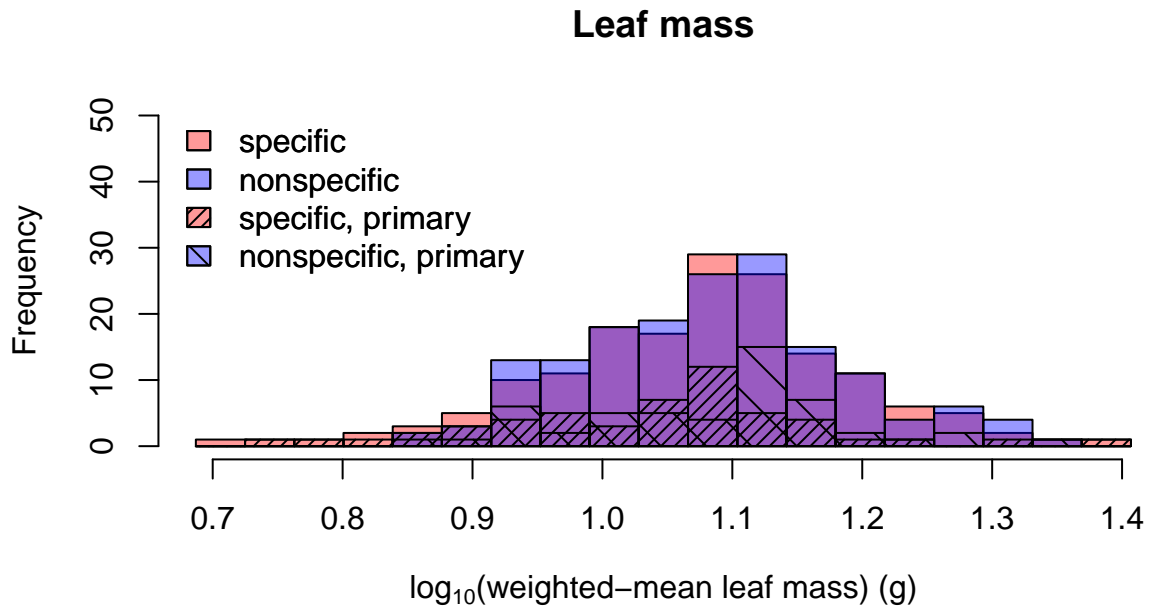
## histogram



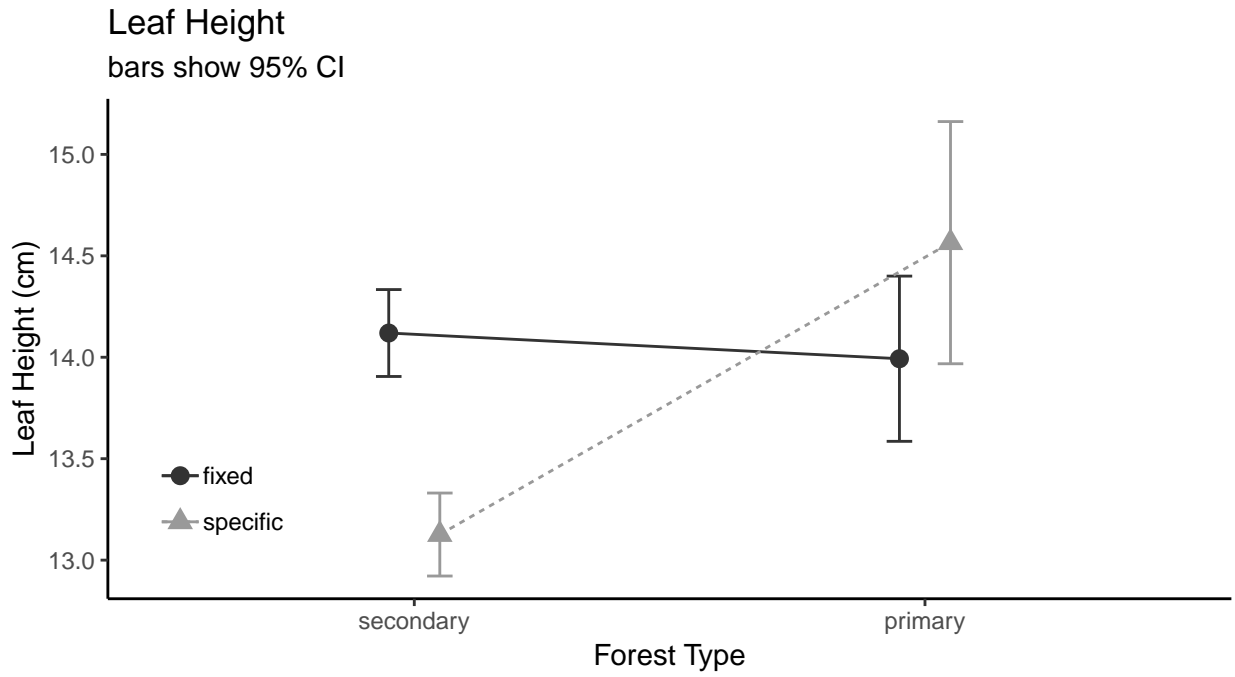
## Leaf Width



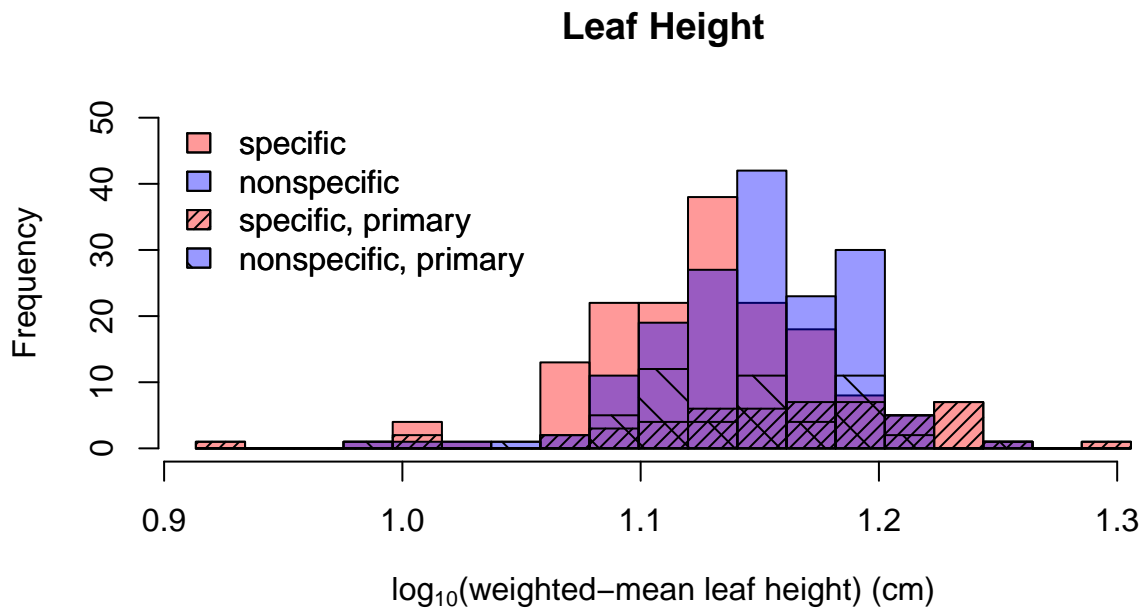
## histogram



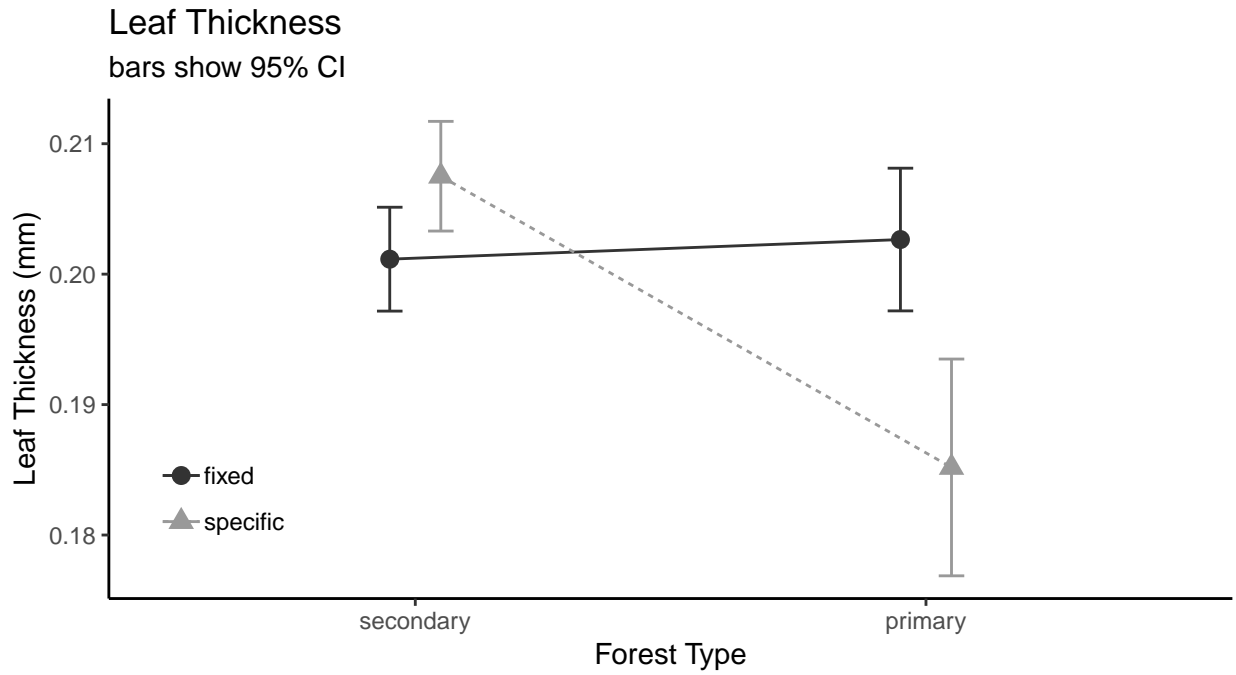
## Leaf Height



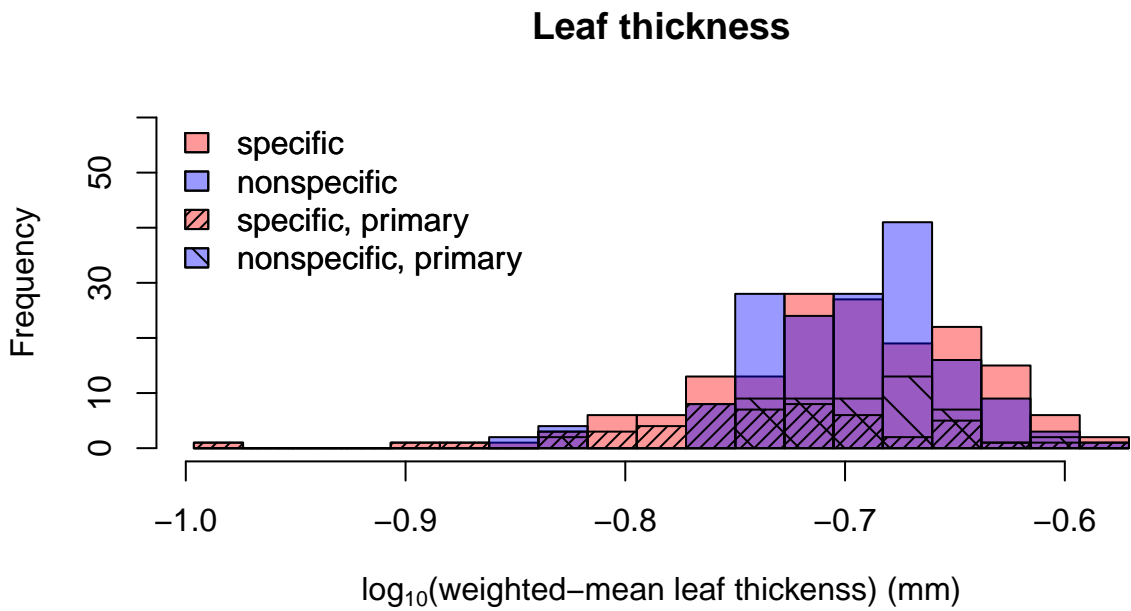
## histogram



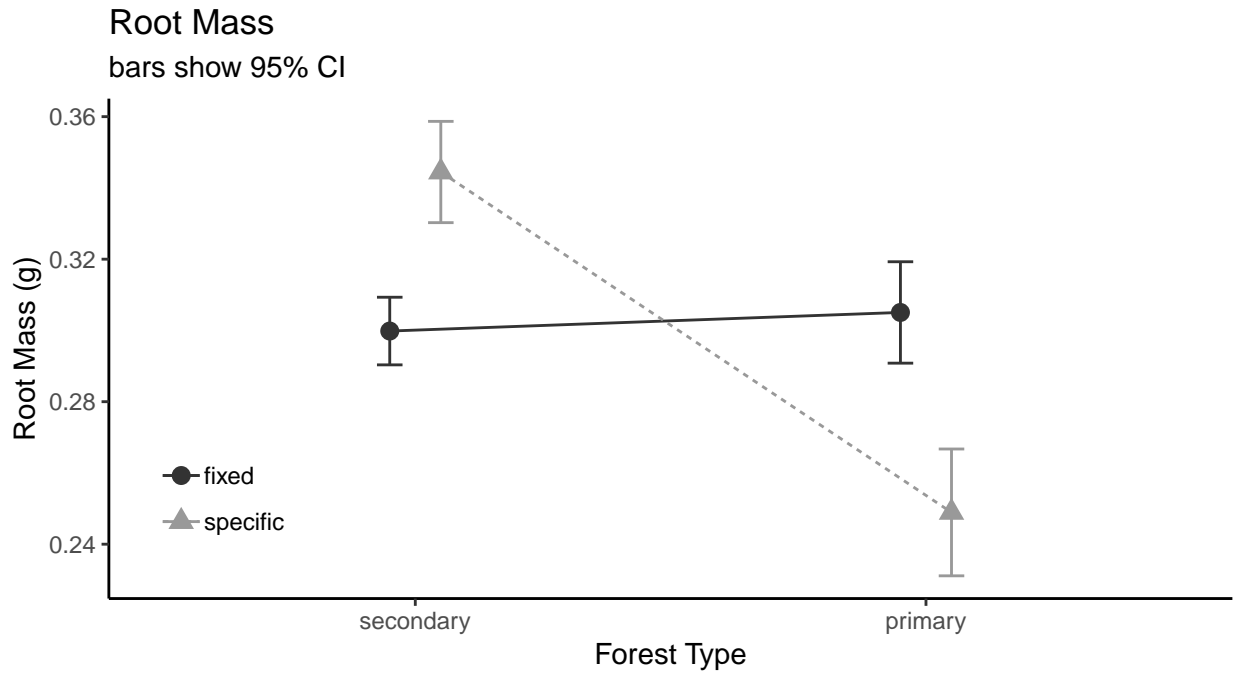
## Leaf Thickness



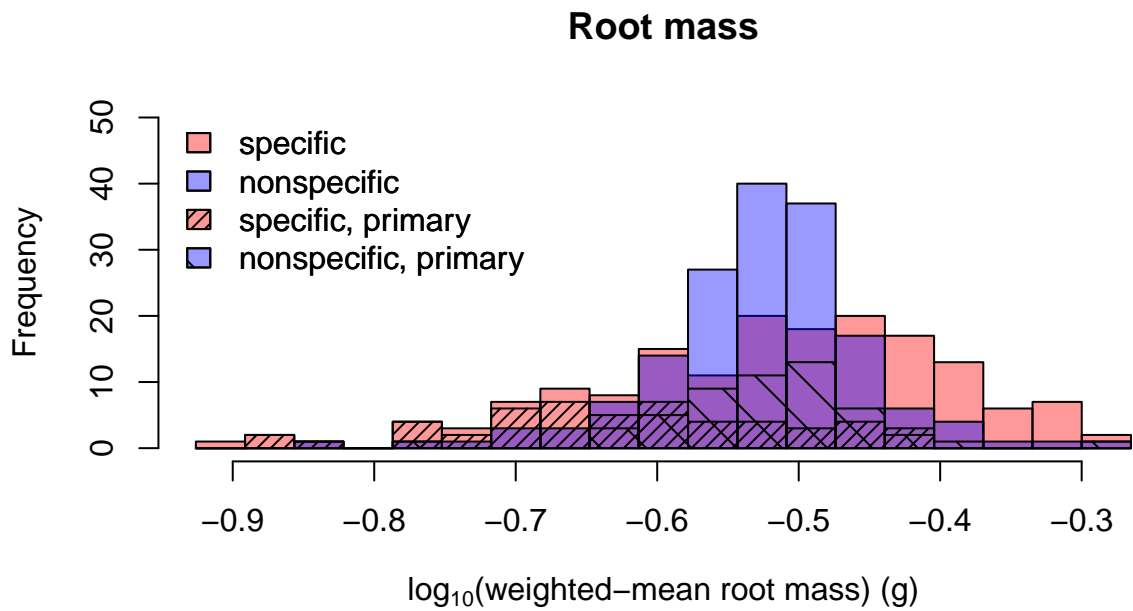
## histogram



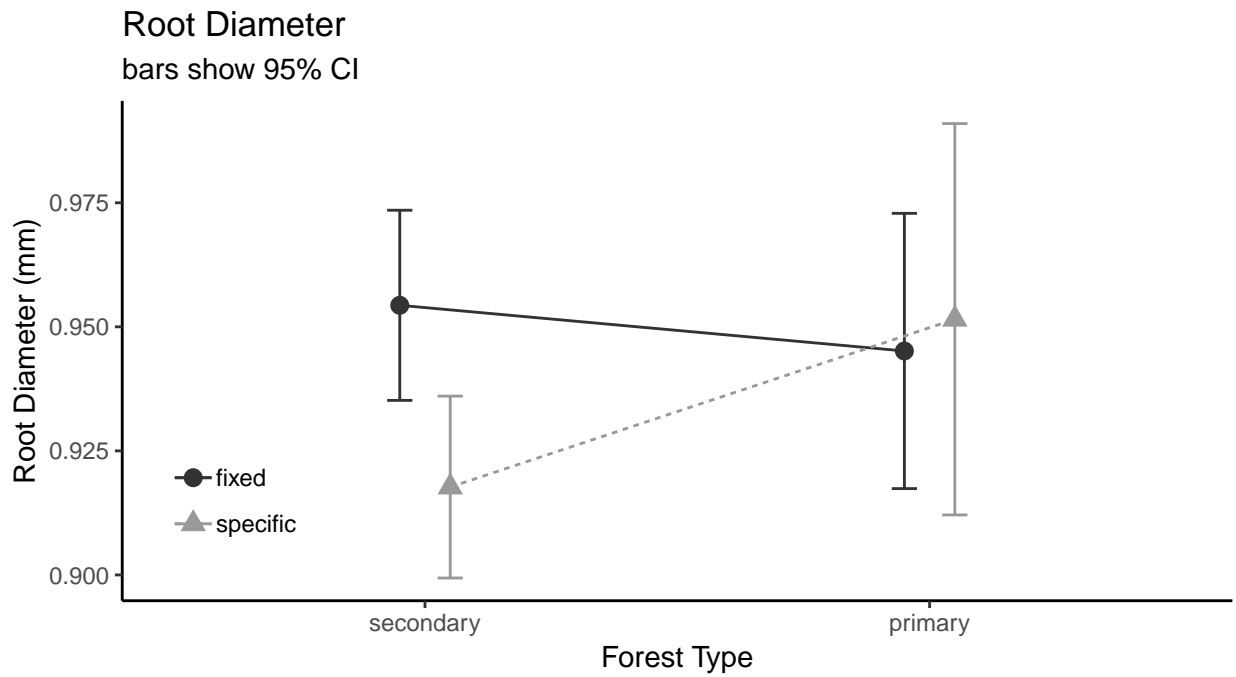
## Root Mass



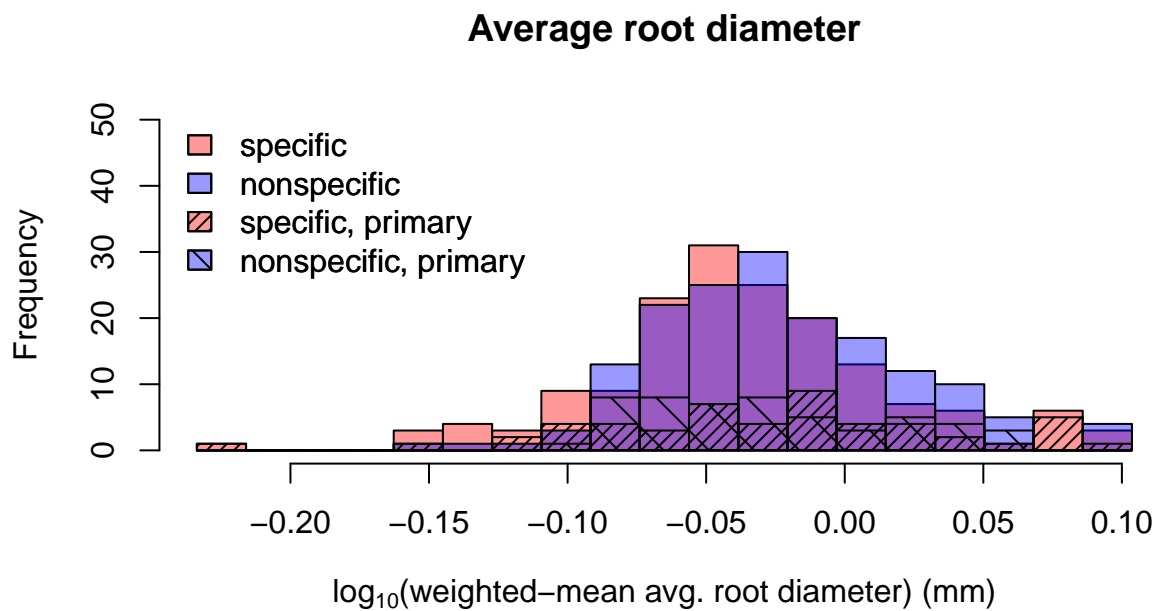
## histogram



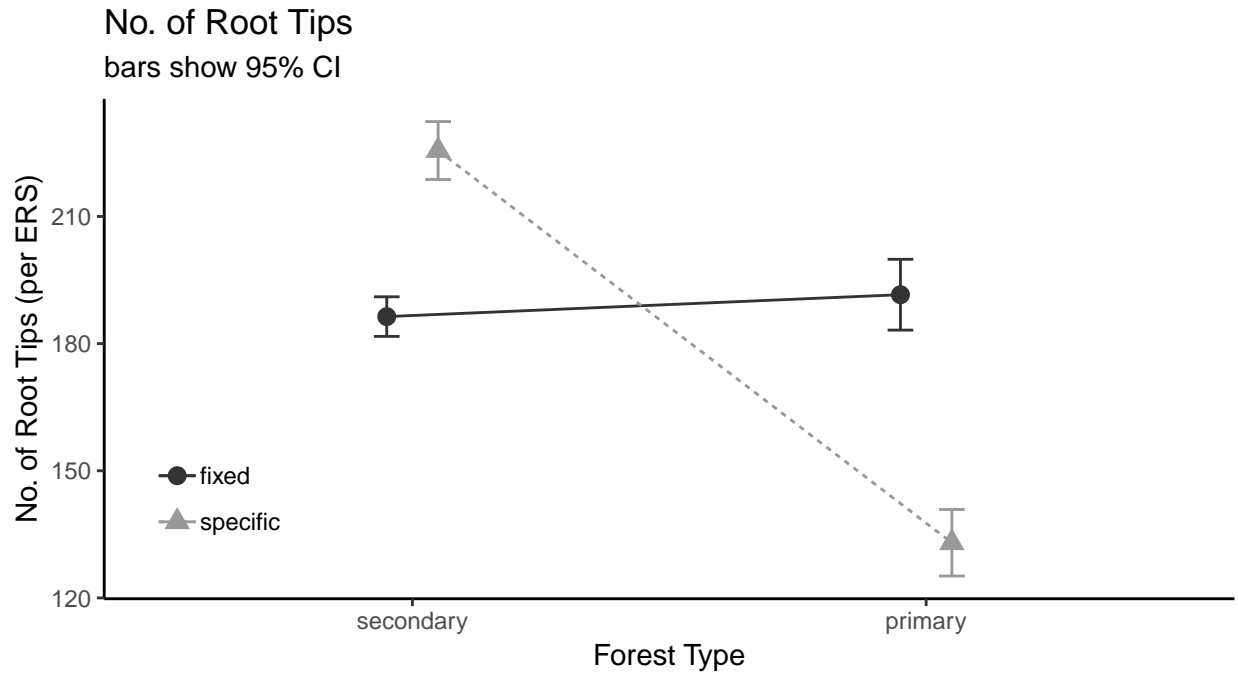
## Avg. Root Diameter



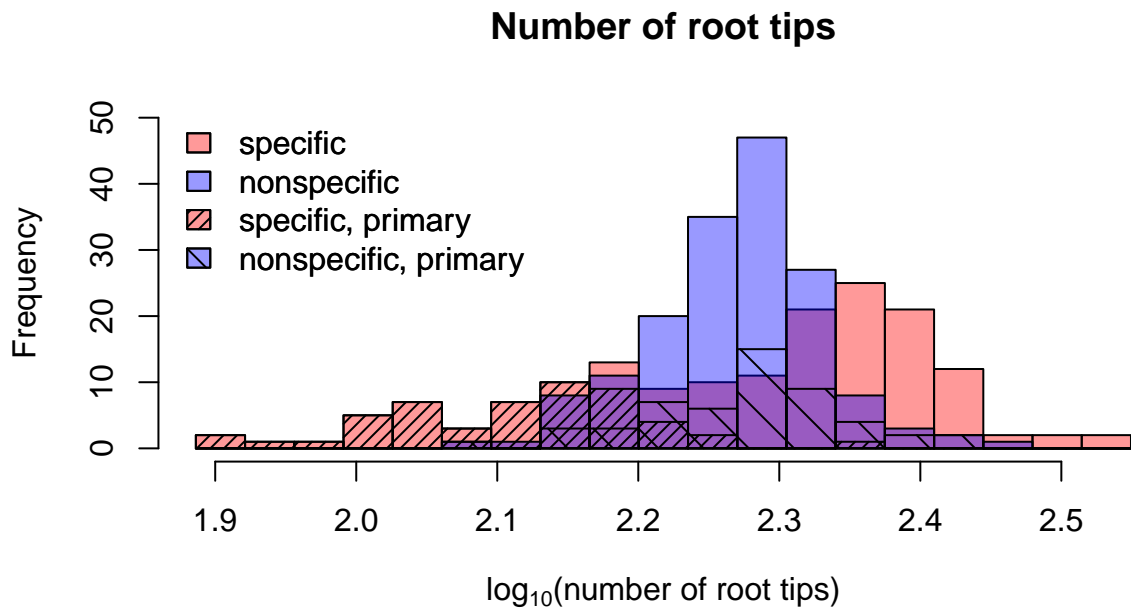
## histogram



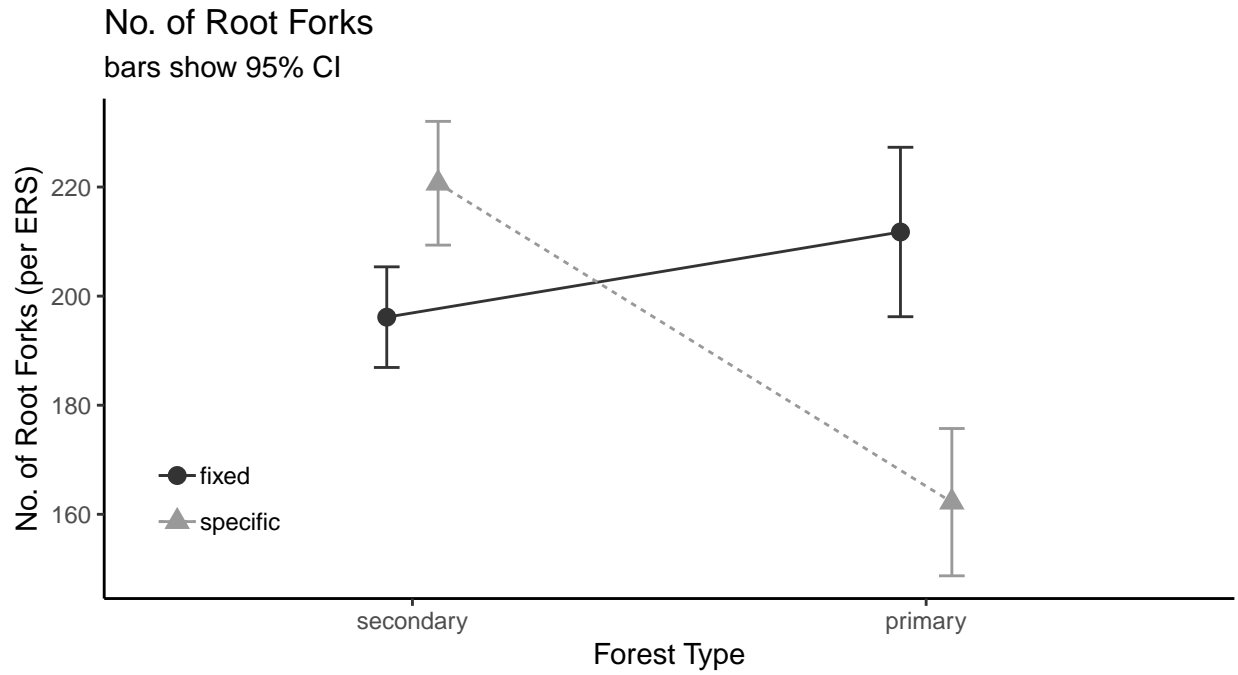
## Number of Root Tips



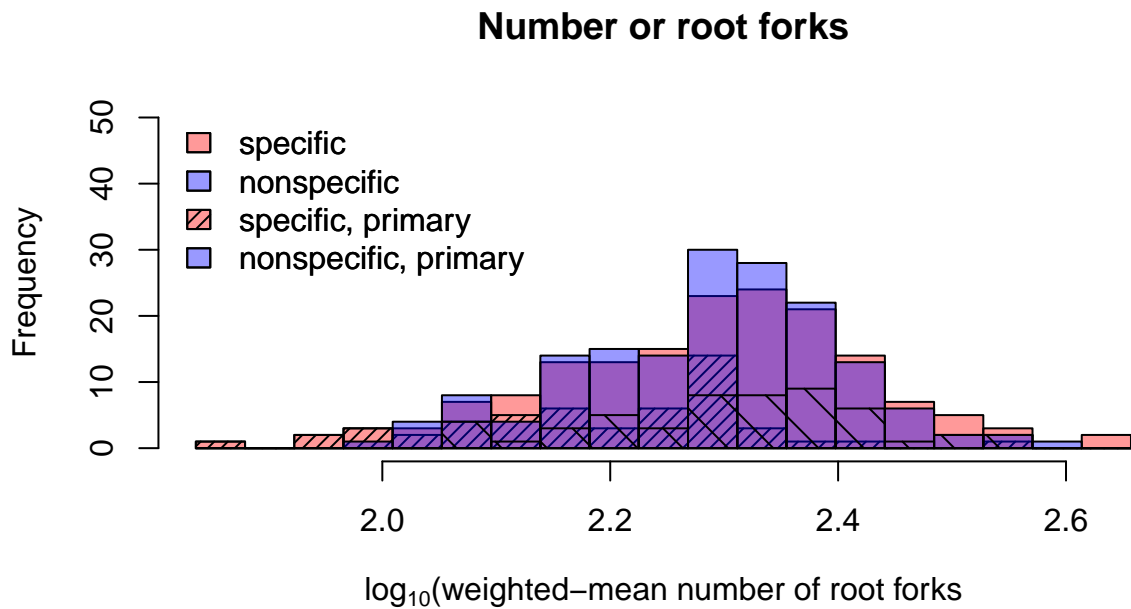
## histogram



## Number of Root Forks

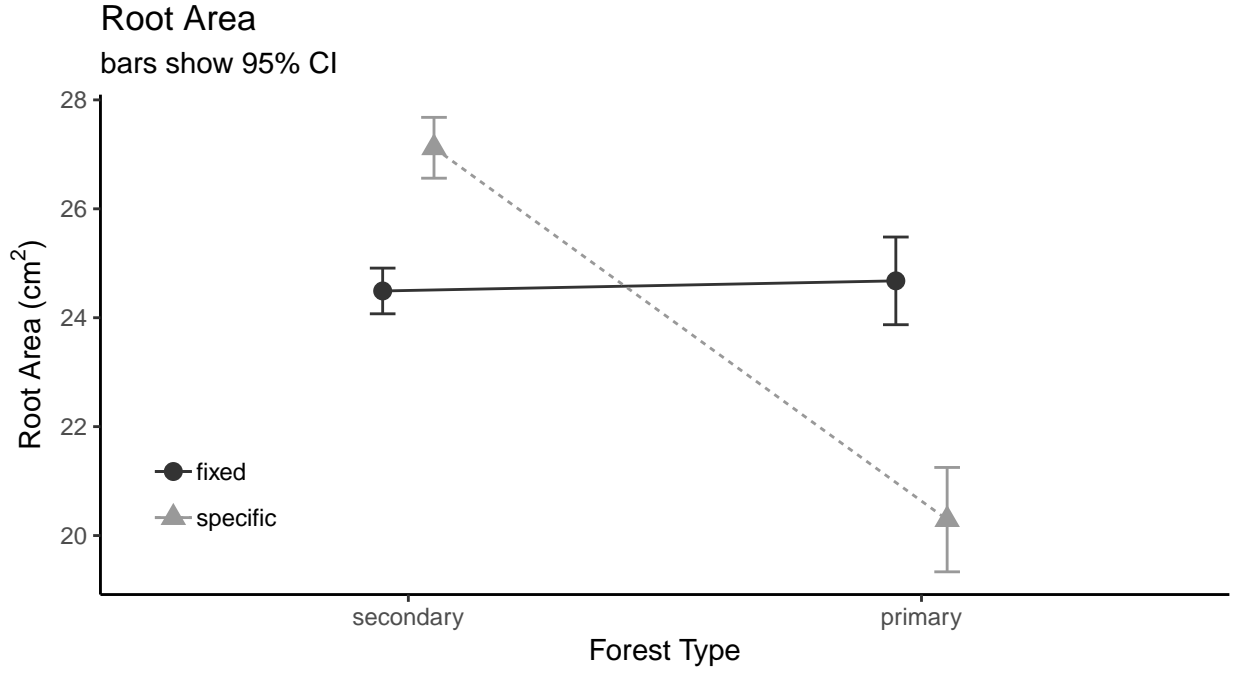


## histogram

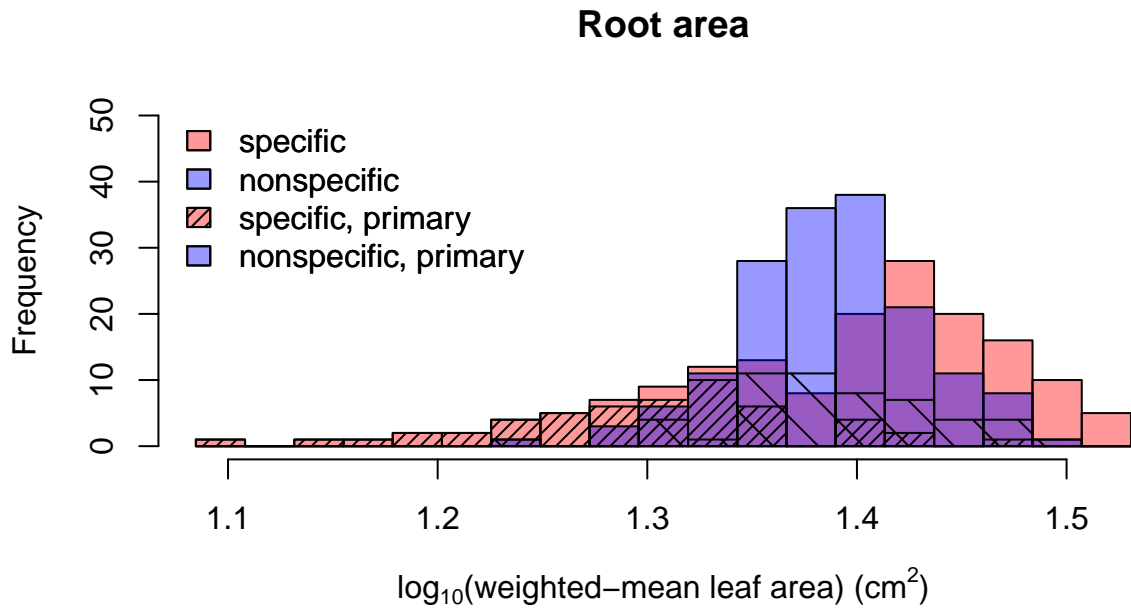




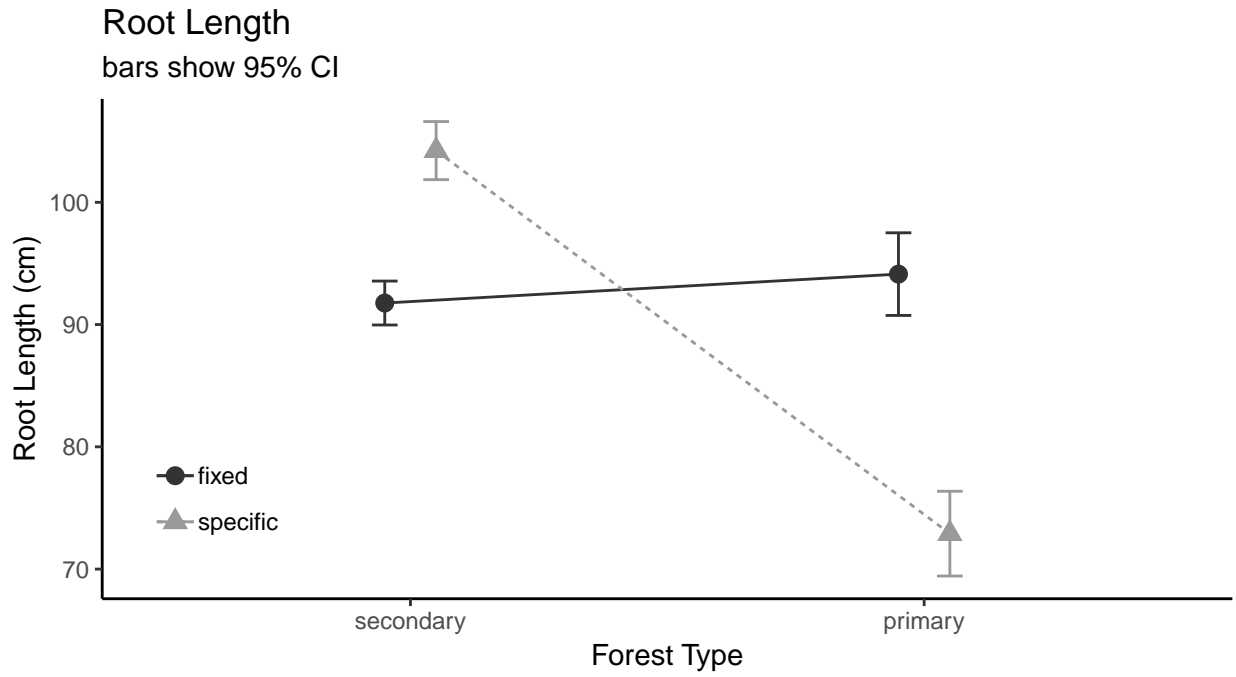
## Root Area



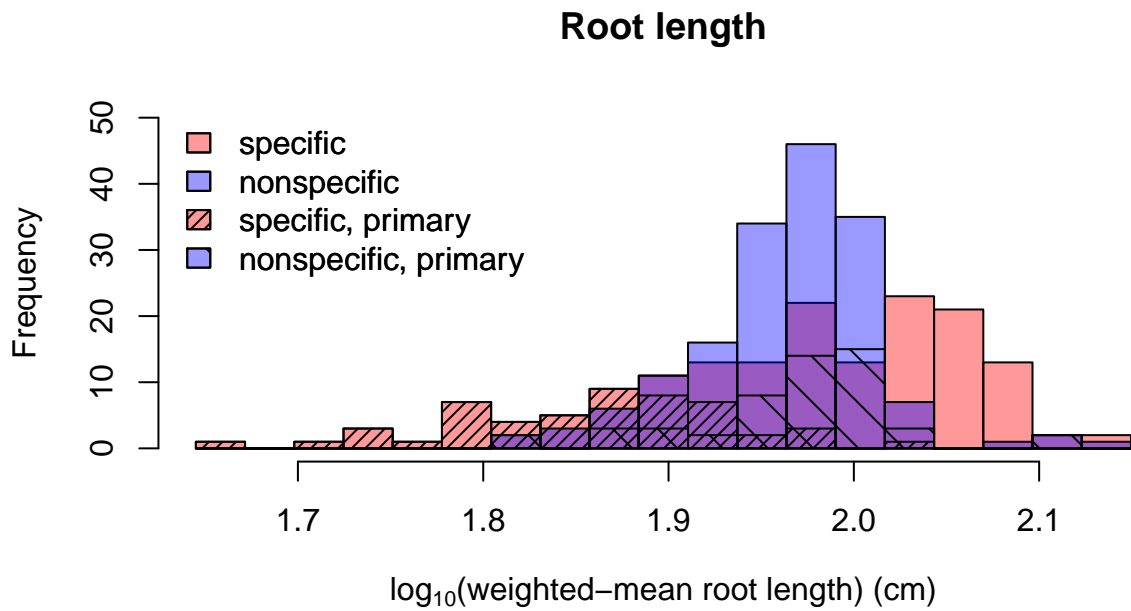
## histogram



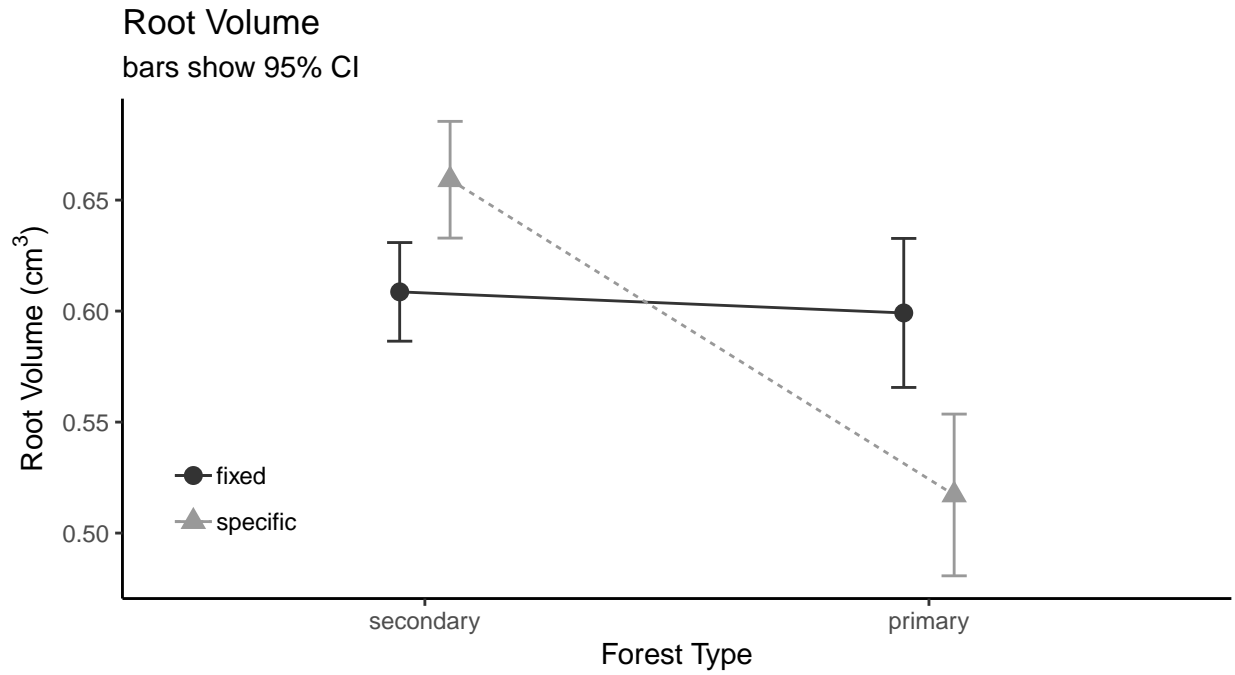
## Root Length



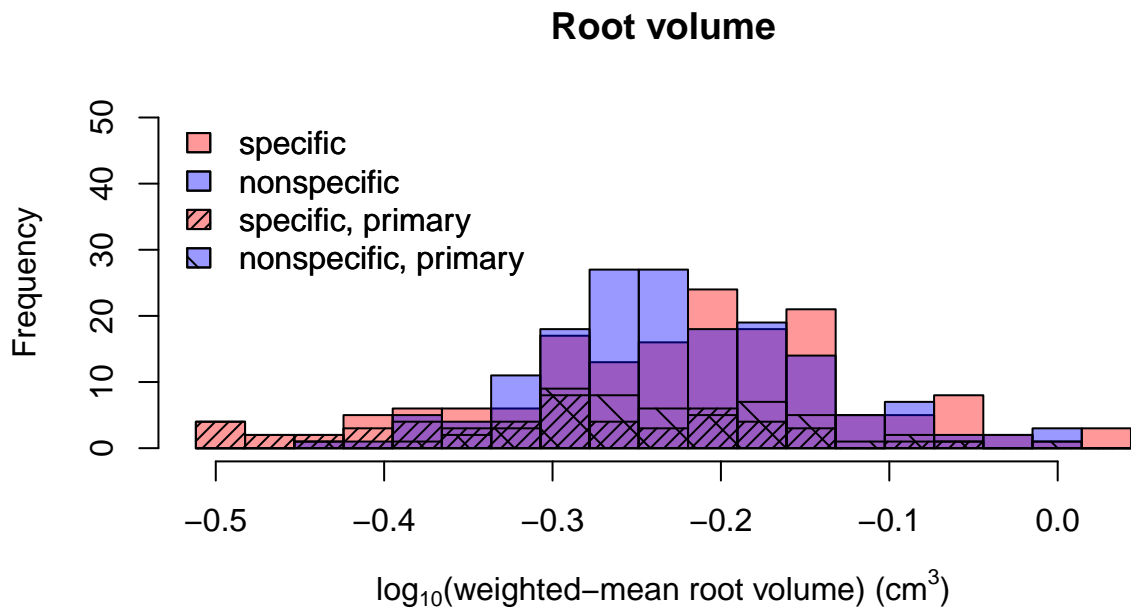
## histogram



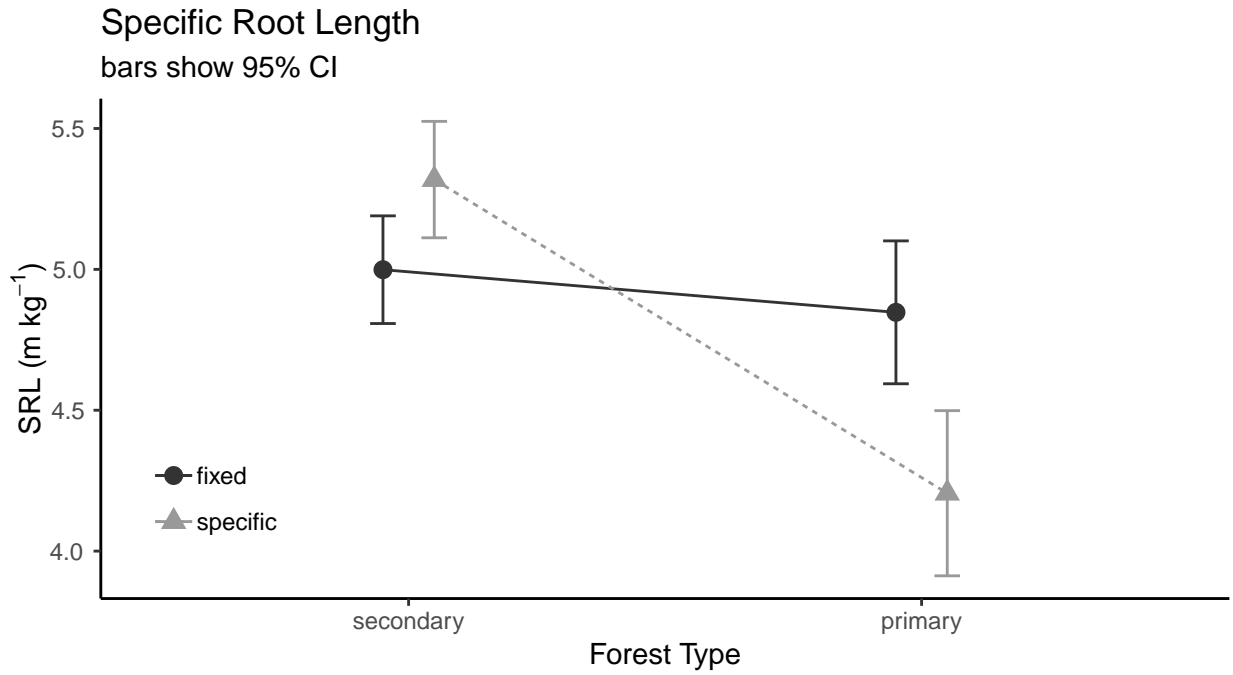
## Root Volume



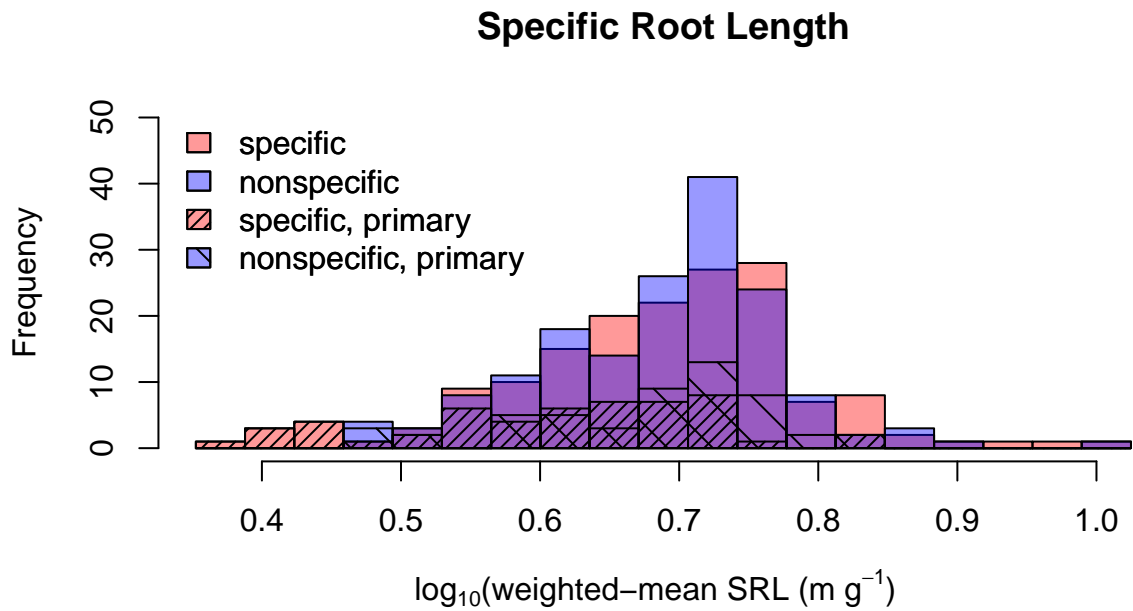
## histogram



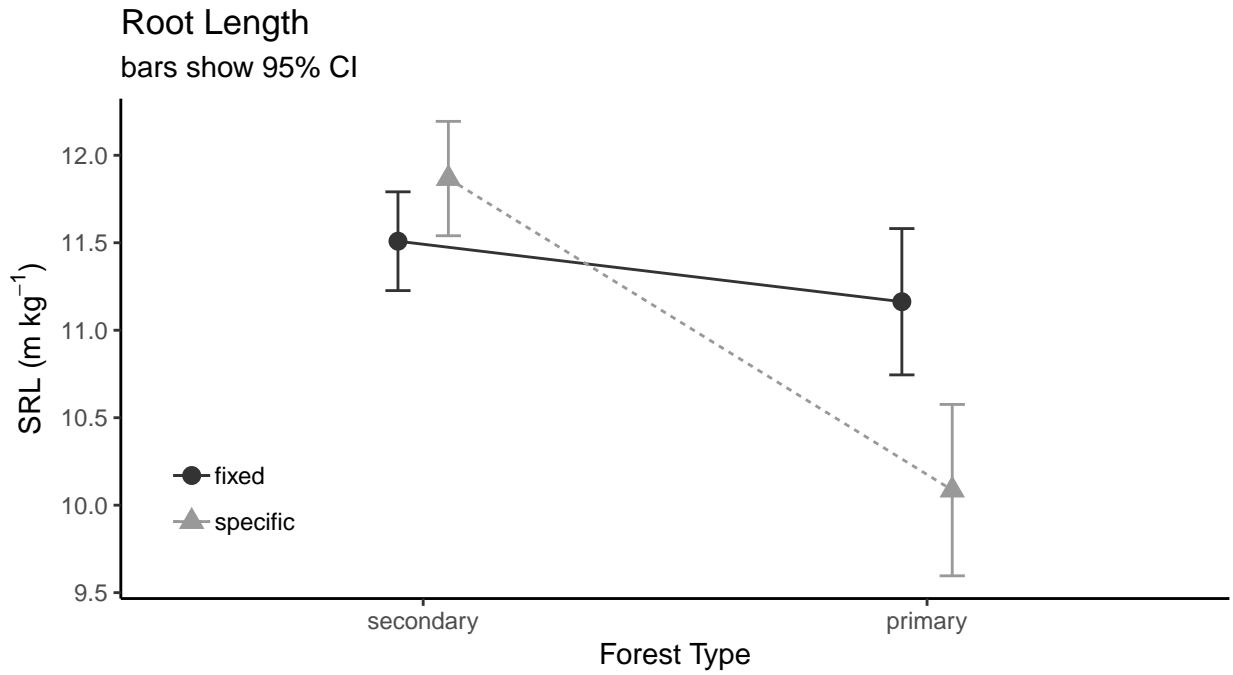
## SRL



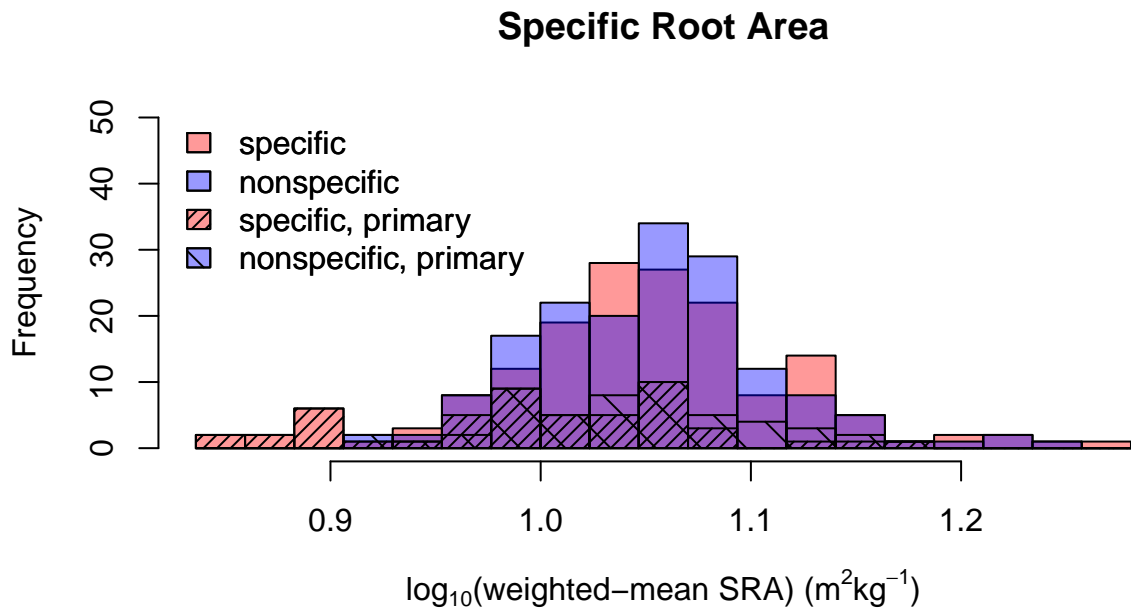
## histogram



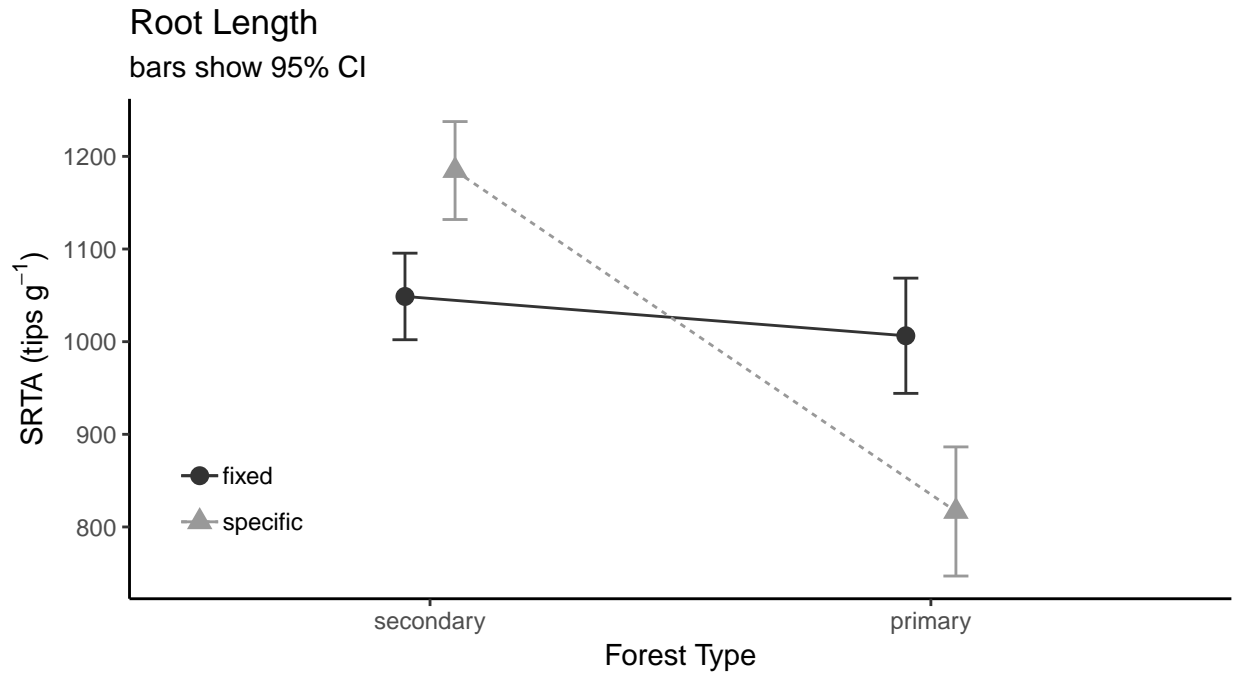
## SRA



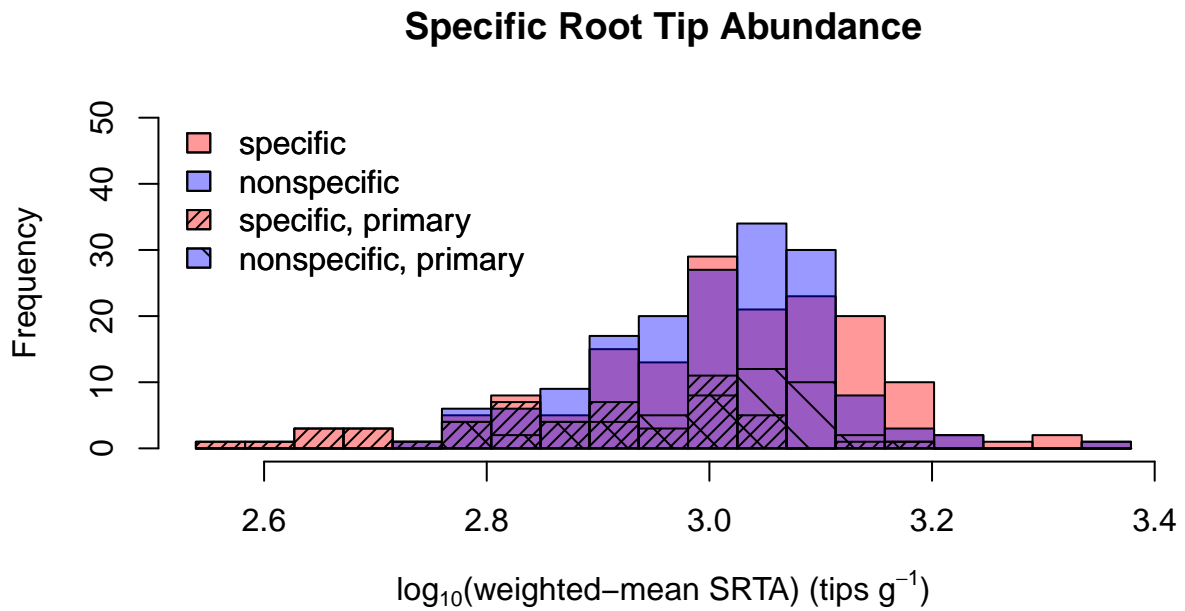
## histogram



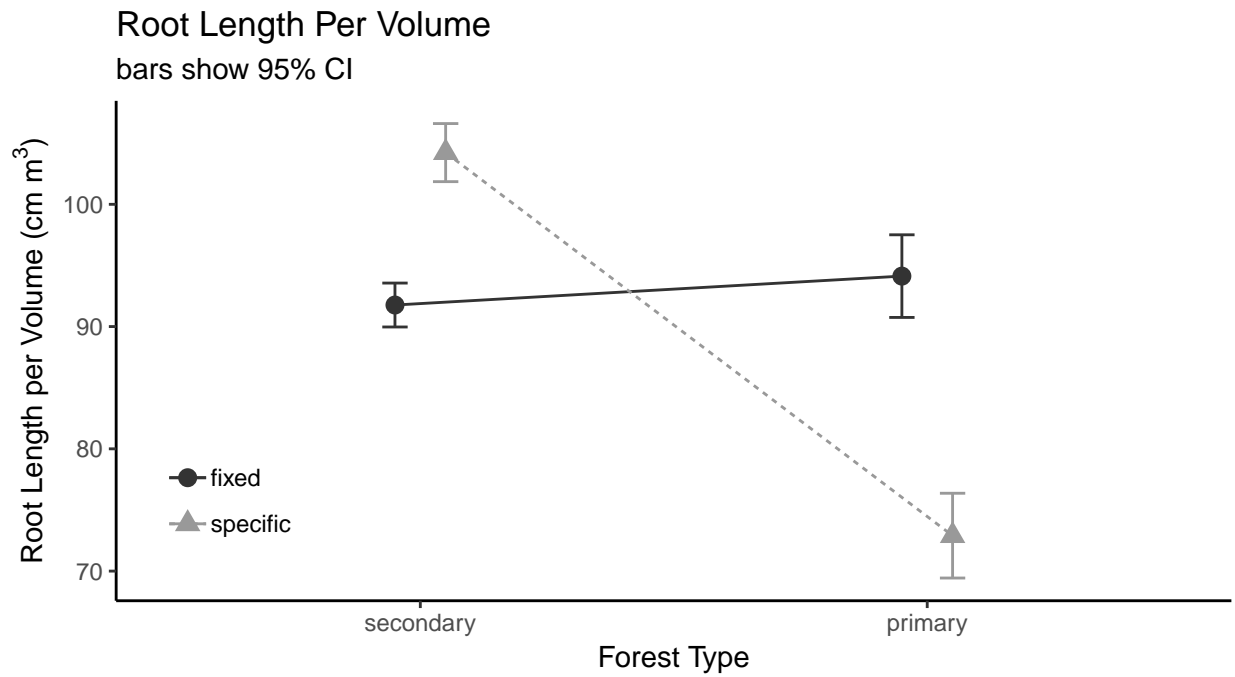
## Specific Root Tip Abundance



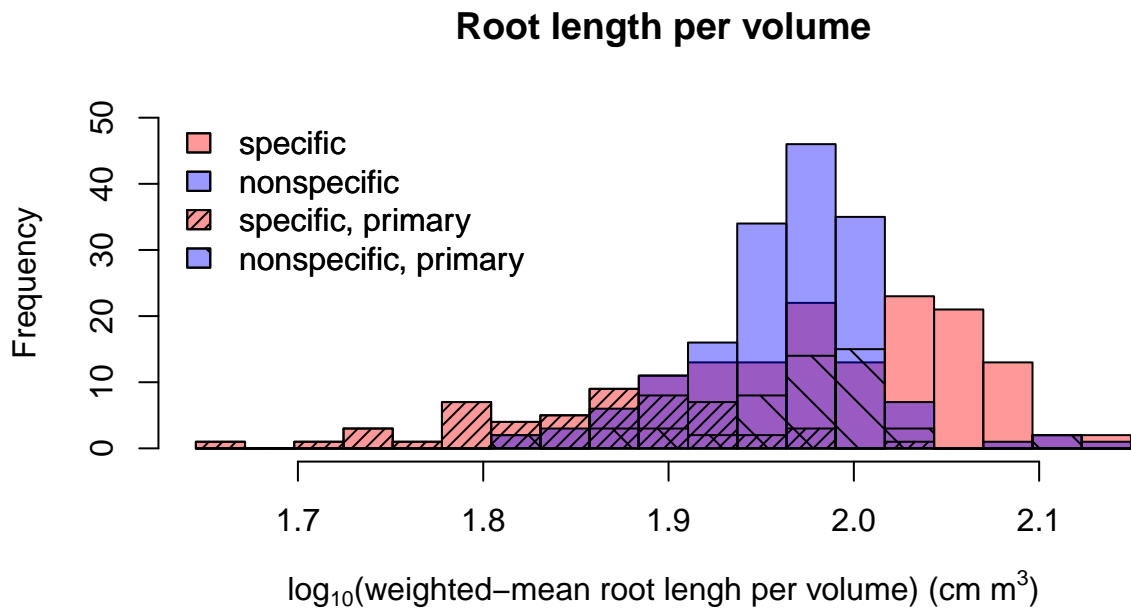
## histogram



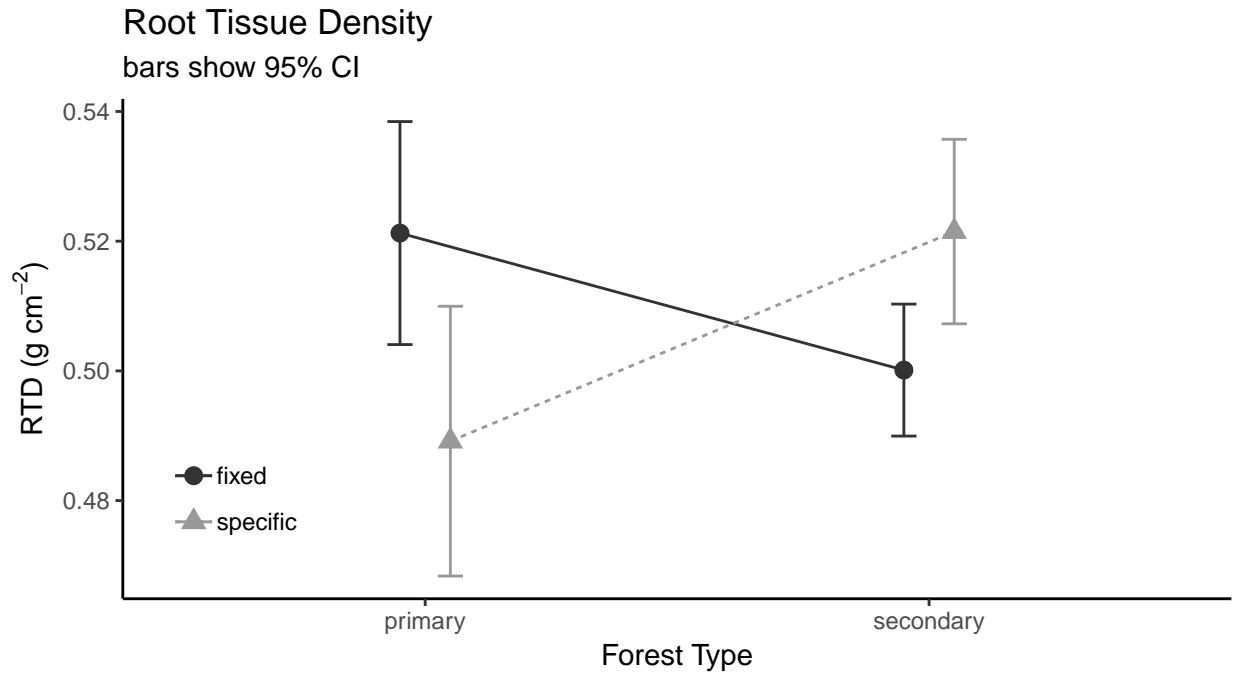
## Root Length Per Volume



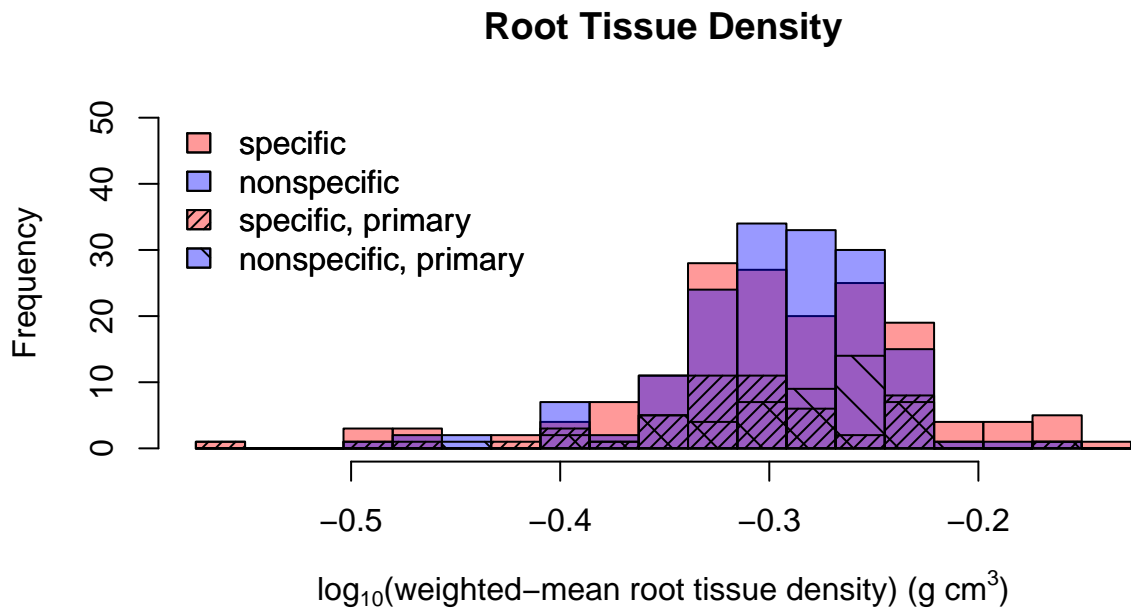
## histogram



## Root Tissue Density

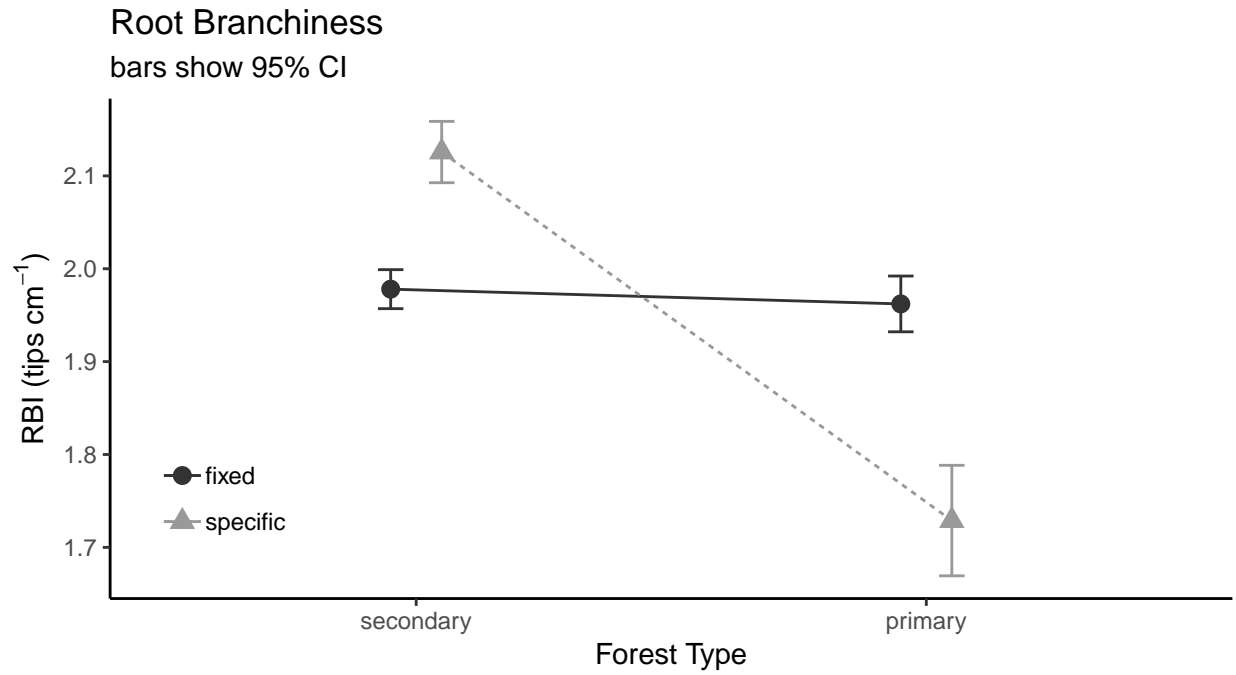


## histogram





## Root Branchiness



## histogram

