Leaf identification

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Topic:

The goal is to propose a method for leaf identification based on the provided leaf attributes and using a proper unsupervised or supervised learning tool.

```
library(ggplot2)
library(cowplot)
library(randomForest)
```

```
## randomForest 4.7-1.1
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```
##
## Attaching package: 'randomForest'
```

```
## The following object is masked from 'package:ggplot2':
##
##     margin
```

Let's read the data and see the first 6 rows.

```
data <- read.csv("leaf.csv", header=FALSE)
head(data)
```

```
##   V1 V2      V3     V4      V5      V6      V7      V8        V9       V10
## 1  1  1 0.72694 1.4742 0.32396 0.98535 1.00000 0.83592 0.0046566 0.0039465
## 2  1  2 0.74173 1.5257 0.36116 0.98152 0.99825 0.79867 0.0052423 0.0050016
## 3  1  3 0.76722 1.5725 0.38998 0.97755 1.00000 0.80812 0.0074573 0.0101210
## 4  1  4 0.73797 1.4597 0.35376 0.97566 1.00000 0.81697 0.0068768 0.0086068
## 5  1  5 0.82301 1.7707 0.44462 0.97698 1.00000 0.75493 0.0074280 0.0100420
## 6  1  6 0.72997 1.4892 0.34284 0.98755 1.00000 0.84482 0.0049451 0.0044506
##         V11      V12       V13        V14       V15     V16
## 1 0.0477900 0.127950 0.0161080 0.00523230 2.7477e-04 1.17560
## 2 0.0241600 0.090476 0.0081195 0.00270800 7.4846e-05 0.69659
## 3 0.0118970 0.057445 0.0032891 0.00092068 3.7886e-05 0.44348
## 4 0.0159500 0.065491 0.0042707 0.00115440 6.6272e-05 0.58785
## 5 0.0079379 0.045339 0.0020514 0.00055986 2.3504e-05 0.34214
## 6 0.0104870 0.058528 0.0034138 0.00112480 2.4798e-05 0.34068
```

Let's give proper columns names to our data

```
colnames(data) <- c("Species","Specimen Number","Eccentricity","AspectRatio","Elongation","Solidity","S
names(data)
```

```
##  [1] "Species"              "Specimen Number"
##  [3] "Eccentricity"         "AspectRatio"
##  [5] "Elongation"           "Solidity"
```

```
##  [7] "Stochastic_Convexity"       "Isoperimetric_Factor"
##  [9] "Maximal_Indentation_Depth" "Lobedness"
## [11] "Average_Intensity"          "Average_Contrast"
## [13] "Smoothness"                 "Third_moment"
## [15] "Uniformity"                 "Entropy"
```

Let's give the proper name of species

```r
last_species_names<-c(1:15,22:36)
new_species_names<-c("Quercus suber","Salix atrocinera","Populus nigra","Alnus sp.","Quercus robur",
    "Crataegus monogyna","Ilex aquifolium","Nerium oleander","Betula pubescens",
    "Tilia tomentosa","Acer palmatum","Celtis sp.","Corylus avellana","Castanea sativa","Populus alba"
    "Primula vulgaris","Erodium sp.","Bougainvillea sp.","Arisarum vulgare","Euonymus japonicus","Ilex
    "Magnolia soulangeana","Buxus sempervirens","Urtica dioica","Podocarpus sp.","Acca sellowiana","Hy
    "Magnolia grandiflora","Geranium sp.")
for(i in last_species_names){
  data[data$Species == i,]$Species <-new_species_names[i]
}
unique(data$Species)
```

```
##  [1] "Quercus suber"            "Salix atrocinera"
##  [3] "Populus nigra"            "Alnus sp."
##  [5] "Quercus robur"            "Crataegus monogyna"
##  [7] "Ilex aquifolium"          "Nerium oleander"
##  [9] "Betula pubescens"         "Tilia tomentosa"
## [11] "Acer palmatum"            "Celtis sp."
## [13] "Corylus avellana"         "Castanea sativa"
## [15] "Populus alba"             "Primula vulgaris"
## [17] "Erodium sp."              "Bougainvillea sp."
## [19] "Arisarum vulgare"         "Euonymus japonicus"
## [21] "Ilex perado ssp. azorica" "Magnolia soulangeana"
## [23] "Buxus sempervirens"       "Urtica dioica"
## [25] "Podocarpus sp."           "Acca sellowiana"
## [27] "Hydrangea sp."            "Pseudosasa japonica"
## [29] "Magnolia grandiflora"     "Geranium sp."
```

let's delete the columns 2 because it is useless for what we want to do

```r
dat<-data[,-2]
head(dat)
```

```
##         Species Eccentricity AspectRatio Elongation Solidity
## 1 Quercus suber      0.72694      1.4742    0.32396  0.98535
## 2 Quercus suber      0.74173      1.5257    0.36116  0.98152
## 3 Quercus suber      0.76722      1.5725    0.38998  0.97755
## 4 Quercus suber      0.73797      1.4597    0.35376  0.97566
## 5 Quercus suber      0.82301      1.7707    0.44462  0.97698
## 6 Quercus suber      0.72997      1.4892    0.34284  0.98755
##   Stochastic_Convexity Isoperimetric_Factor Maximal_Indentation_Depth Lobedness
## 1              1.00000              0.83592                 0.0046566 0.0039465
## 2              0.99825              0.79867                 0.0052423 0.0050016
## 3              1.00000              0.80812                 0.0074573 0.0101210
## 4              1.00000              0.81697                 0.0068768 0.0086068
## 5              1.00000              0.75493                 0.0074280 0.0100420
## 6              1.00000              0.84482                 0.0049451 0.0044506
##   Average_Intensity Average_Contrast Smoothness Third_moment Uniformity Entropy
```

```
## 1          0.0477900              0.127950  0.0161080      0.00523230 2.7477e-04 1.17560
## 2          0.0241600              0.090476  0.0081195      0.00270800 7.4846e-05 0.69659
## 3          0.0118970              0.057445  0.0032891      0.00092068 3.7886e-05 0.44348
## 4          0.0159500              0.065491  0.0042707      0.00115440 6.6272e-05 0.58785
## 5          0.0079379              0.045339  0.0020514      0.00055986 2.3504e-05 0.34214
## 6          0.0104870              0.058528  0.0034138      0.00112480 2.4798e-05 0.34068
```

```
dat$Species <- as.factor(dat$Species)
str(dat)
```

```
## 'data.frame':    340 obs. of  15 variables:
##  $ Species                 : Factor w/ 30 levels "Acca sellowiana",..: 27 27 27 27 27 27 27 27 27 2
##  $ Eccentricity            : num  0.727 0.742 0.767 0.738 0.823 ...
##  $ AspectRatio             : num  1.47 1.53 1.57 1.46 1.77 ...
##  $ Elongation              : num  0.324 0.361 0.39 0.354 0.445 ...
##  $ Solidity                : num  0.985 0.982 0.978 0.976 0.977 ...
##  $ Stochastic_Convexity    : num  1 0.998 1 1 1 ...
##  $ Isoperimetric_Factor    : num  0.836 0.799 0.808 0.817 0.755 ...
##  $ Maximal_Indentation_Depth: num  0.00466 0.00524 0.00746 0.00688 0.00743 ...
##  $ Lobedness               : num  0.00395 0.005 0.01012 0.00861 0.01004 ...
##  $ Average_Intensity       : num  0.04779 0.02416 0.0119 0.01595 0.00794 ...
##  $ Average_Contrast        : num  0.128 0.0905 0.0574 0.0655 0.0453 ...
##  $ Smoothness              : num  0.01611 0.00812 0.00329 0.00427 0.00205 ...
##  $ Third_moment            : num  0.005232 0.002708 0.000921 0.001154 0.00056 ...
##  $ Uniformity              : num  2.75e-04 7.48e-05 3.79e-05 6.63e-05 2.35e-05 ...
##  $ Entropy                 : num  1.176 0.697 0.443 0.588 0.342 ...
```

```
summary(dat)
```

```
##                  Species      Eccentricity      AspectRatio       Elongation
##  Acer palmatum      : 16   Min.   :0.1171   Min.   : 1.007   Min.   :0.1076
##  Betula pubescens   : 14   1st Qu.:0.5506   1st Qu.: 1.211   1st Qu.:0.3496
##  Bougainvillea sp.  : 13   Median :0.7634   Median : 1.571   Median :0.5019
##  Corylus avellana   : 13   Mean   :0.7199   Mean   : 2.440   Mean   :0.5138
##  Tilia tomentosa    : 13   3rd Qu.:0.8951   3rd Qu.: 2.343   3rd Qu.:0.6334
##  Buxus sempervirens : 12   Max.   :0.9987   Max.   :19.038   Max.   :0.9483
##  (Other)            :259
##     Solidity      Stochastic_Convexity Isoperimetric_Factor
##  Min.   :0.4855   Min.   :0.3965       Min.   :0.07838
##  1st Qu.:0.8907   1st Qu.:0.9662       1st Qu.:0.34682
##  Median :0.9481   Median :0.9930       Median :0.57916
##  Mean   :0.9042   Mean   :0.9438       Mean   :0.53123
##  3rd Qu.:0.9769   3rd Qu.:1.0000       3rd Qu.:0.70071
##  Max.   :0.9939   Max.   :1.0000       Max.   :0.85816
##
##  Maximal_Indentation_Depth   Lobedness        Average_Intensity
##  Min.   :0.002837          Min.   :0.001464   Min.   :0.005022
##  1st Qu.:0.009521          1st Qu.:0.016500   1st Qu.:0.022843
##  Median :0.023860          Median :0.103615   Median :0.042087
##  Mean   :0.037345          Mean   :0.523845   Mean   :0.051346
##  3rd Qu.:0.047834          3rd Qu.:0.416432   3rd Qu.:0.073046
##  Max.   :0.198980          Max.   :7.206200   Max.   :0.190670
##
##  Average_Contrast   Smoothness        Third_moment         Uniformity
##  Min.   :0.03342   Min.   :0.001115   Min.   :0.0002294   Min.   :6.924e-06
```

```
##  1st Qu.:0.08336   1st Qu.:0.006901   1st Qu.:0.0020796   1st Qu.:1.023e-04
##  Median :0.11937   Median :0.014050   Median :0.0044468   Median :2.387e-04
##  Mean   :0.12453   Mean   :0.017670   Mean   :0.0059277   Mean   :3.872e-04
##  3rd Qu.:0.16379   3rd Qu.:0.026128   3rd Qu.:0.0083069   3rd Qu.:5.162e-04
##  Max.   :0.28081   Max.   :0.073089   Max.   :0.0297860   Max.   :2.936e-03
##
##      Entropy
##  Min.   :0.1694
##  1st Qu.:0.7189
##  Median :1.0775
##  Mean   :1.1626
##  3rd Qu.:1.5546
##  Max.   :2.7085
##
```

we will check the number available for each species

```
table(dat$Species)
```

```
##
##          Acca sellowiana           Acer palmatum              Alnus sp.
##                       11                      16                      8
##          Arisarum vulgare         Betula pubescens        Bougainvillea sp.
##                        9                      14                     13
##        Buxus sempervirens          Castanea sativa              Celtis sp.
##                       12                      12                     12
##          Corylus avellana       Crataegus monogyna             Erodium sp.
##                       13                       8                     11
##        Euonymus japonicus             Geranium sp.            Hydrangea sp.
##                       12                      10                     11
##          Ilex aquifolium Ilex perado ssp. azorica    Magnolia grandiflora
##                       10                      11                     11
##      Magnolia soulangeana          Nerium oleander           Podocarpus sp.
##                       12                      11                     11
##              Populus alba            Populus nigra         Primula vulgaris
##                       10                      10                     12
##        Pseudosasa japonica            Quercus robur            Quercus suber
##                       11                      12                     12
##          Salix atrocinera         Tilia tomentosa            Urtica dioica
##                       10                      13                     12
```

Let partition our data by creating two independent samples.

```
set.seed(42)
ind<-sample(2, nrow(dat), replace=TRUE, prob=c(0.7,0.3))
train<-dat[ind==1,]
test<-dat[ind==2,]
```

Let's run the random forest

```
#set.seed(42)
model <- randomForest(Species ~ ., data=train, ntree=1000)
#model
```

```
attributes(model)
```

```
## $names
##  [1] "call"          "type"          "predicted"      "err.rate"
```

```
##  [5] "confusion"       "votes"          "oob.times"       "classes"
##  [9] "importance"      "importanceSD"   "localImportance" "proximity"
## [13] "ntree"           "mtry"           "forest"          "y"
## [17] "test"            "inbag"          "terms"
##
## $class
## [1] "randomForest.formula" "randomForest"
```

Let's start prediction and come out with the confusion matrix on train data

```
library(caret)
```

```
## Loading required package: lattice
```

```
prediction1 <- predict(model, train)
print(head(prediction1))
```

```
##             3             5             6             8             9
## Quercus suber Quercus suber Quercus suber Quercus suber Quercus suber
##            11
## Quercus suber
## 30 Levels: Acca sellowiana Acer palmatum Alnus sp. ... Urtica dioica
```

```
print(head(train$Species))
```

```
## [1] Quercus suber Quercus suber Quercus suber Quercus suber Quercus suber
## [6] Quercus suber
## 30 Levels: Acca sellowiana Acer palmatum Alnus sp. ... Urtica dioica
```

Let's do a confusion matrix

```
#it is in the caret package
confusionMatrix(prediction1,train$Species)
```

```
## Confusion Matrix and Statistics
##
##                          Reference
## Prediction                Acca sellowiana Acer palmatum Alnus sp.
##    Acca sellowiana                      8             0         0
##    Acer palmatum                        0            13         0
##    Alnus sp.                            0             0         6
##    Arisarum vulgare                     0             0         0
##    Betula pubescens                     0             0         0
##    Bougainvillea sp.                    0             0         0
##    Buxus sempervirens                   0             0         0
##    Castanea sativa                      0             0         0
##    Celtis sp.                           0             0         0
##    Corylus avellana                     0             0         0
##    Crataegus monogyna                   0             0         0
##    Erodium sp.                          0             0         0
##    Euonymus japonicus                   0             0         0
##    Geranium sp.                         0             0         0
##    Hydrangea sp.                        0             0         0
##    Ilex aquifolium                      0             0         0
##    Ilex perado ssp. azorica             0             0         0
##    Magnolia grandiflora                 0             0         0
##    Magnolia soulangeana                 0             0         0
##    Nerium oleander                      0             0         0
```

```
##    Podocarpus sp.                          0          0          0
##    Populus alba                            0          0          0
##    Populus nigra                           0          0          0
##    Primula vulgaris                        0          0          0
##    Pseudosasa japonica                     0          0          0
##    Quercus robur                           0          0          0
##    Quercus suber                           0          0          0
##    Salix atrocinera                        0          0          0
##    Tilia tomentosa                         0          0          0
##    Urtica dioica                           0          0          0
##                                Reference
## Prediction              Arisarum vulgare Betula pubescens Bougainvillea sp.
##    Acca sellowiana                      0                0                 0
##    Acer palmatum                        0                0                 0
##    Alnus sp.                            0                0                 0
##    Arisarum vulgare                     8                0                 0
##    Betula pubescens                     0               11                 0
##    Bougainvillea sp.                    0                0                 8
##    Buxus sempervirens                   0                0                 0
##    Castanea sativa                      0                0                 0
##    Celtis sp.                           0                0                 0
##    Corylus avellana                     0                0                 0
##    Crataegus monogyna                   0                0                 0
##    Erodium sp.                          0                0                 0
##    Euonymus japonicus                   0                0                 0
##    Geranium sp.                         0                0                 0
##    Hydrangea sp.                        0                0                 0
##    Ilex aquifolium                      0                0                 0
##    Ilex perado ssp. azorica             0                0                 0
##    Magnolia grandiflora                 0                0                 0
##    Magnolia soulangeana                 0                0                 0
##    Nerium oleander                      0                0                 0
##    Podocarpus sp.                       0                0                 0
##    Populus alba                         0                0                 0
##    Populus nigra                        0                0                 0
##    Primula vulgaris                     0                0                 0
##    Pseudosasa japonica                  0                0                 0
##    Quercus robur                        0                0                 0
##    Quercus suber                        0                0                 0
##    Salix atrocinera                     0                0                 0
##    Tilia tomentosa                      0                0                 0
##    Urtica dioica                        0                0                 0
##                                Reference
## Prediction              Buxus sempervirens Castanea sativa Celtis sp.
##    Acca sellowiana                       0               0          0
##    Acer palmatum                         0               0          0
##    Alnus sp.                             0               0          0
##    Arisarum vulgare                      0               0          0
##    Betula pubescens                      0               0          0
##    Bougainvillea sp.                     0               0          0
##    Buxus sempervirens                   10               0          0
##    Castanea sativa                       0               8          0
##    Celtis sp.                            0               0          5
##    Corylus avellana                      0               0          0
```

```
##    Crataegus monogyna                         0             0           0
##    Erodium sp.                                0             0           0
##    Euonymus japonicus                         0             0           0
##    Geranium sp.                               0             0           0
##    Hydrangea sp.                              0             0           0
##    Ilex aquifolium                            0             0           0
##    Ilex perado ssp. azorica                   0             0           0
##    Magnolia grandiflora                       0             0           0
##    Magnolia soulangeana                       0             0           0
##    Nerium oleander                            0             0           0
##    Podocarpus sp.                             0             0           0
##    Populus alba                               0             0           0
##    Populus nigra                              0             0           0
##    Primula vulgaris                           0             0           0
##    Pseudosasa japonica                        0             0           0
##    Quercus robur                              0             0           0
##    Quercus suber                              0             0           0
##    Salix atrocinera                           0             0           0
##    Tilia tomentosa                            0             0           0
##    Urtica dioica                              0             0           0
##                             Reference
## Prediction                 Corylus avellana Crataegus monogyna Erodium sp.
##    Acca sellowiana                         0                  0           0
##    Acer palmatum                           0                  0           0
##    Alnus sp.                               0                  0           0
##    Arisarum vulgare                        0                  0           0
##    Betula pubescens                        0                  0           0
##    Bougainvillea sp.                       0                  0           0
##    Buxus sempervirens                      0                  0           0
##    Castanea sativa                         0                  0           0
##    Celtis sp.                              0                  0           0
##    Corylus avellana                        7                  0           0
##    Crataegus monogyna                      0                  6           0
##    Erodium sp.                             0                  0           6
##    Euonymus japonicus                      0                  0           0
##    Geranium sp.                            0                  0           0
##    Hydrangea sp.                           0                  0           0
##    Ilex aquifolium                         0                  0           0
##    Ilex perado ssp. azorica                0                  0           0
##    Magnolia grandiflora                    0                  0           0
##    Magnolia soulangeana                    0                  0           0
##    Nerium oleander                         0                  0           0
##    Podocarpus sp.                          0                  0           0
##    Populus alba                            0                  0           0
##    Populus nigra                           0                  0           0
##    Primula vulgaris                        0                  0           0
##    Pseudosasa japonica                     0                  0           0
##    Quercus robur                           0                  0           0
##    Quercus suber                           0                  0           0
##    Salix atrocinera                        0                  0           0
##    Tilia tomentosa                         0                  0           0
##    Urtica dioica                           0                  0           0
##                             Reference
## Prediction                 Euonymus japonicus Geranium sp. Hydrangea sp.
```

```
##     Acca sellowiana                         0            0            0
##     Acer palmatum                           0            0            0
##     Alnus sp.                               0            0            0
##     Arisarum vulgare                        0            0            0
##     Betula pubescens                        0            0            0
##     Bougainvillea sp.                       0            0            0
##     Buxus sempervirens                      0            0            0
##     Castanea sativa                         0            0            0
##     Celtis sp.                              0            0            0
##     Corylus avellana                        0            0            0
##     Crataegus monogyna                      0            0            0
##     Erodium sp.                             0            0            0
##     Euonymus japonicus                      9            0            0
##     Geranium sp.                            0            8            0
##     Hydrangea sp.                           0            0            9
##     Ilex aquifolium                         0            0            0
##     Ilex perado ssp. azorica                0            0            0
##     Magnolia grandiflora                    0            0            0
##     Magnolia soulangeana                    0            0            0
##     Nerium oleander                         0            0            0
##     Podocarpus sp.                          0            0            0
##     Populus alba                            0            0            0
##     Populus nigra                           0            0            0
##     Primula vulgaris                        0            0            0
##     Pseudosasa japonica                     0            0            0
##     Quercus robur                           0            0            0
##     Quercus suber                           0            0            0
##     Salix atrocinera                        0            0            0
##     Tilia tomentosa                         0            0            0
##     Urtica dioica                           0            0            0
##                             Reference
## Prediction                   Ilex aquifolium Ilex perado ssp. azorica
##     Acca sellowiana                        0                        0
##     Acer palmatum                          0                        0
##     Alnus sp.                              0                        0
##     Arisarum vulgare                       0                        0
##     Betula pubescens                       0                        0
##     Bougainvillea sp.                      0                        0
##     Buxus sempervirens                     0                        0
##     Castanea sativa                        0                        0
##     Celtis sp.                             0                        0
##     Corylus avellana                       0                        0
##     Crataegus monogyna                     0                        0
##     Erodium sp.                            0                        0
##     Euonymus japonicus                     0                        0
##     Geranium sp.                           0                        0
##     Hydrangea sp.                          0                        0
##     Ilex aquifolium                        6                        0
##     Ilex perado ssp. azorica               0                        8
##     Magnolia grandiflora                   0                        0
##     Magnolia soulangeana                   0                        0
##     Nerium oleander                        0                        0
##     Podocarpus sp.                         0                        0
##     Populus alba                           0                        0
```

```
##    Populus nigra                      0                  0
##    Primula vulgaris                   0                  0
##    Pseudosasa japonica                0                  0
##    Quercus robur                      0                  0
##    Quercus suber                      0                  0
##    Salix atrocinera                   0                  0
##    Tilia tomentosa                    0                  0
##    Urtica dioica                      0                  0
##                           Reference
## Prediction                Magnolia grandiflora Magnolia soulangeana
##    Acca sellowiana                           0                    0
##    Acer palmatum                             0                    0
##    Alnus sp.                                 0                    0
##    Arisarum vulgare                          0                    0
##    Betula pubescens                          0                    0
##    Bougainvillea sp.                         0                    0
##    Buxus sempervirens                        0                    0
##    Castanea sativa                           0                    0
##    Celtis sp.                                0                    0
##    Corylus avellana                          0                    0
##    Crataegus monogyna                        0                    0
##    Erodium sp.                               0                    0
##    Euonymus japonicus                        0                    0
##    Geranium sp.                              0                    0
##    Hydrangea sp.                             0                    0
##    Ilex aquifolium                           0                    0
##    Ilex perado ssp. azorica                  0                    0
##    Magnolia grandiflora                      6                    0
##    Magnolia soulangeana                      0                   11
##    Nerium oleander                           0                    0
##    Podocarpus sp.                            0                    0
##    Populus alba                              0                    0
##    Populus nigra                             0                    0
##    Primula vulgaris                          0                    0
##    Pseudosasa japonica                       0                    0
##    Quercus robur                             0                    0
##    Quercus suber                             0                    0
##    Salix atrocinera                          0                    0
##    Tilia tomentosa                           0                    0
##    Urtica dioica                             0                    0
##                           Reference
## Prediction                Nerium oleander Podocarpus sp. Populus alba
##    Acca sellowiana                      0              0            0
##    Acer palmatum                        0              0            0
##    Alnus sp.                            0              0            0
##    Arisarum vulgare                     0              0            0
##    Betula pubescens                     0              0            0
##    Bougainvillea sp.                    0              0            0
##    Buxus sempervirens                   0              0            0
##    Castanea sativa                      0              0            0
##    Celtis sp.                           0              0            0
##    Corylus avellana                     0              0            0
##    Crataegus monogyna                   0              0            0
##    Erodium sp.                          0              0            0
```

```
##      Euonymus japonicus                       0              0              0
##      Geranium sp.                             0              0              0
##      Hydrangea sp.                            0              0              0
##      Ilex aquifolium                          0              0              0
##      Ilex perado ssp. azorica                 0              0              0
##      Magnolia grandiflora                     0              0              0
##      Magnolia soulangeana                     0              0              0
##      Nerium oleander                         10              0              0
##      Podocarpus sp.                           0             10              0
##      Populus alba                             0              0              9
##      Populus nigra                            0              0              0
##      Primula vulgaris                         0              0              0
##      Pseudosasa japonica                      0              0              0
##      Quercus robur                            0              0              0
##      Quercus suber                            0              0              0
##      Salix atrocinera                         0              0              0
##      Tilia tomentosa                          0              0              0
##      Urtica dioica                            0              0              0
##                              Reference
## Prediction                   Populus nigra Primula vulgaris Pseudosasa japonica
##      Acca sellowiana                     0                0                   0
##      Acer palmatum                       0                0                   0
##      Alnus sp.                           0                0                   0
##      Arisarum vulgare                    0                0                   0
##      Betula pubescens                    0                0                   0
##      Bougainvillea sp.                   0                0                   0
##      Buxus sempervirens                  0                0                   0
##      Castanea sativa                     0                0                   0
##      Celtis sp.                          0                0                   0
##      Corylus avellana                    0                0                   0
##      Crataegus monogyna                  0                0                   0
##      Erodium sp.                         0                0                   0
##      Euonymus japonicus                  0                0                   0
##      Geranium sp.                        0                0                   0
##      Hydrangea sp.                       0                0                   0
##      Ilex aquifolium                     0                0                   0
##      Ilex perado ssp. azorica            0                0                   0
##      Magnolia grandiflora                0                0                   0
##      Magnolia soulangeana                0                0                   0
##      Nerium oleander                     0                0                   0
##      Podocarpus sp.                      0                0                   0
##      Populus alba                        0                0                   0
##      Populus nigra                       4                0                   0
##      Primula vulgaris                    0                7                   0
##      Pseudosasa japonica                 0                0                   8
##      Quercus robur                       0                0                   0
##      Quercus suber                       0                0                   0
##      Salix atrocinera                    0                0                   0
##      Tilia tomentosa                     0                0                   0
##      Urtica dioica                       0                0                   0
##                              Reference
## Prediction                   Quercus robur Quercus suber Salix atrocinera
##      Acca sellowiana                     0             0                0
##      Acer palmatum                       0             0                0
```

```
##    Alnus sp.                          0          0          0
##    Arisarum vulgare                   0          0          0
##    Betula pubescens                   0          0          0
##    Bougainvillea sp.                  0          0          0
##    Buxus sempervirens                 0          0          0
##    Castanea sativa                    0          0          0
##    Celtis sp.                         0          0          0
##    Corylus avellana                   0          0          0
##    Crataegus monogyna                 0          0          0
##    Erodium sp.                        0          0          0
##    Euonymus japonicus                 0          0          0
##    Geranium sp.                       0          0          0
##    Hydrangea sp.                      0          0          0
##    Ilex aquifolium                    0          0          0
##    Ilex perado ssp. azorica           0          0          0
##    Magnolia grandiflora               0          0          0
##    Magnolia soulangeana               0          0          0
##    Nerium oleander                    0          0          0
##    Podocarpus sp.                     0          0          0
##    Populus alba                       0          0          0
##    Populus nigra                      0          0          0
##    Primula vulgaris                   0          0          0
##    Pseudosasa japonica                0          0          0
##    Quercus robur                      8          0          0
##    Quercus suber                      0          6          0
##    Salix atrocinera                   0          0          6
##    Tilia tomentosa                    0          0          0
##    Urtica dioica                      0          0          0
##                          Reference
## Prediction        Tilia tomentosa Urtica dioica
##    Acca sellowiana                0             0
##    Acer palmatum                  0             0
##    Alnus sp.                      0             0
##    Arisarum vulgare               0             0
##    Betula pubescens               0             0
##    Bougainvillea sp.              0             0
##    Buxus sempervirens             0             0
##    Castanea sativa                0             0
##    Celtis sp.                     0             0
##    Corylus avellana               0             0
##    Crataegus monogyna             0             0
##    Erodium sp.                    0             0
##    Euonymus japonicus             0             0
##    Geranium sp.                   0             0
##    Hydrangea sp.                  0             0
##    Ilex aquifolium                0             0
##    Ilex perado ssp. azorica       0             0
##    Magnolia grandiflora           0             0
##    Magnolia soulangeana           0             0
##    Nerium oleander                0             0
##    Podocarpus sp.                 0             0
##    Populus alba                   0             0
##    Populus nigra                  0             0
##    Primula vulgaris               0             0
```

```
##    Pseudosasa japonica                        0              0
##    Quercus robur                              0              0
##    Quercus suber                              0              0
##    Salix atrocinera                           0              0
##    Tilia tomentosa                            7              0
##    Urtica dioica                              0              6
##
## Overall Statistics
##
##                   Accuracy : 1
##                     95% CI : (0.9844, 1)
##      No Information Rate : 0.0556
##      P-Value [Acc > NIR] : < 2.2e-16
##
##                      Kappa : 1
##
##   Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                       Class: Acca sellowiana Class: Acer palmatum
## Sensitivity                        1.00000              1.00000
## Specificity                        1.00000              1.00000
## Pos Pred Value                     1.00000              1.00000
## Neg Pred Value                     1.00000              1.00000
## Prevalence                         0.03419              0.05556
## Detection Rate                     0.03419              0.05556
## Detection Prevalence               0.03419              0.05556
## Balanced Accuracy                  1.00000              1.00000
##                       Class: Alnus sp. Class: Arisarum vulgare
## Sensitivity                   1.00000              1.00000
## Specificity                   1.00000              1.00000
## Pos Pred Value                1.00000              1.00000
## Neg Pred Value                1.00000              1.00000
## Prevalence                    0.02564              0.03419
## Detection Rate                0.02564              0.03419
## Detection Prevalence          0.02564              0.03419
## Balanced Accuracy             1.00000              1.00000
##                       Class: Betula pubescens Class: Bougainvillea sp.
## Sensitivity                          1.00000                  1.00000
## Specificity                          1.00000                  1.00000
## Pos Pred Value                       1.00000                  1.00000
## Neg Pred Value                       1.00000                  1.00000
## Prevalence                           0.04701                  0.03419
## Detection Rate                       0.04701                  0.03419
## Detection Prevalence                 0.04701                  0.03419
## Balanced Accuracy                    1.00000                  1.00000
##                       Class: Buxus sempervirens Class: Castanea sativa
## Sensitivity                            1.00000                1.00000
## Specificity                            1.00000                1.00000
## Pos Pred Value                         1.00000                1.00000
## Neg Pred Value                         1.00000                1.00000
## Prevalence                             0.04274                0.03419
## Detection Rate                         0.04274                0.03419
```

```
## Detection Prevalence                      0.04274                 0.03419
## Balanced Accuracy                          1.00000                 1.00000
##                     Class: Celtis sp. Class: Corylus avellana
## Sensitivity                  1.00000                   1.00000
## Specificity                  1.00000                   1.00000
## Pos Pred Value               1.00000                   1.00000
## Neg Pred Value               1.00000                   1.00000
## Prevalence                   0.02137                   0.02991
## Detection Rate               0.02137                   0.02991
## Detection Prevalence         0.02137                   0.02991
## Balanced Accuracy            1.00000                   1.00000
##                     Class: Crataegus monogyna Class: Erodium sp.
## Sensitivity                          1.00000              1.00000
## Specificity                          1.00000              1.00000
## Pos Pred Value                       1.00000              1.00000
## Neg Pred Value                       1.00000              1.00000
## Prevalence                           0.02564              0.02564
## Detection Rate                       0.02564              0.02564
## Detection Prevalence                 0.02564              0.02564
## Balanced Accuracy                    1.00000              1.00000
##                     Class: Euonymus japonicus Class: Geranium sp.
## Sensitivity                          1.00000              1.00000
## Specificity                          1.00000              1.00000
## Pos Pred Value                       1.00000              1.00000
## Neg Pred Value                       1.00000              1.00000
## Prevalence                           0.03846              0.03419
## Detection Rate                       0.03846              0.03419
## Detection Prevalence                 0.03846              0.03419
## Balanced Accuracy                    1.00000              1.00000
##                     Class: Hydrangea sp. Class: Ilex aquifolium
## Sensitivity                     1.00000                  1.00000
## Specificity                     1.00000                  1.00000
## Pos Pred Value                  1.00000                  1.00000
## Neg Pred Value                  1.00000                  1.00000
## Prevalence                      0.03846                  0.02564
## Detection Rate                  0.03846                  0.02564
## Detection Prevalence            0.03846                  0.02564
## Balanced Accuracy               1.00000                  1.00000
##                     Class: Ilex perado ssp. azorica
## Sensitivity                             1.00000
## Specificity                             1.00000
## Pos Pred Value                          1.00000
## Neg Pred Value                          1.00000
## Prevalence                              0.03419
## Detection Rate                          0.03419
## Detection Prevalence                    0.03419
## Balanced Accuracy                       1.00000
##                     Class: Magnolia grandiflora Class: Magnolia soulangeana
## Sensitivity                            1.00000                     1.00000
## Specificity                            1.00000                     1.00000
## Pos Pred Value                         1.00000                     1.00000
## Neg Pred Value                         1.00000                     1.00000
## Prevalence                             0.02564                     0.04701
## Detection Rate                         0.02564                     0.04701
```

```
## Detection Prevalence                       0.02564                    0.04701
## Balanced Accuracy                           1.00000                    1.00000
##                      Class: Nerium oleander Class: Podocarpus sp.
## Sensitivity                                1.00000                    1.00000
## Specificity                                1.00000                    1.00000
## Pos Pred Value                             1.00000                    1.00000
## Neg Pred Value                             1.00000                    1.00000
## Prevalence                                 0.04274                    0.04274
## Detection Rate                             0.04274                    0.04274
## Detection Prevalence                       0.04274                    0.04274
## Balanced Accuracy                          1.00000                    1.00000
##                      Class: Populus alba Class: Populus nigra
## Sensitivity                             1.00000                    1.00000
## Specificity                             1.00000                    1.00000
## Pos Pred Value                          1.00000                    1.00000
## Neg Pred Value                          1.00000                    1.00000
## Prevalence                              0.03846                    0.01709
## Detection Rate                          0.03846                    0.01709
## Detection Prevalence                    0.03846                    0.01709
## Balanced Accuracy                       1.00000                    1.00000
##                      Class: Primula vulgaris Class: Pseudosasa japonica
## Sensitivity                                 1.00000                       1.00000
## Specificity                                 1.00000                       1.00000
## Pos Pred Value                              1.00000                       1.00000
## Neg Pred Value                              1.00000                       1.00000
## Prevalence                                  0.02991                       0.03419
## Detection Rate                              0.02991                       0.03419
## Detection Prevalence                        0.02991                       0.03419
## Balanced Accuracy                           1.00000                       1.00000
##                      Class: Quercus robur Class: Quercus suber
## Sensitivity                              1.00000                    1.00000
## Specificity                              1.00000                    1.00000
## Pos Pred Value                           1.00000                    1.00000
## Neg Pred Value                           1.00000                    1.00000
## Prevalence                               0.03419                    0.02564
## Detection Rate                           0.03419                    0.02564
## Detection Prevalence                     0.03419                    0.02564
## Balanced Accuracy                        1.00000                    1.00000
##                      Class: Salix atrocinera Class: Tilia tomentosa
## Sensitivity                                 1.00000                    1.00000
## Specificity                                 1.00000                    1.00000
## Pos Pred Value                              1.00000                    1.00000
## Neg Pred Value                              1.00000                    1.00000
## Prevalence                                  0.02564                    0.02991
## Detection Rate                              0.02564                    0.02991
## Detection Prevalence                        0.02564                    0.02991
## Balanced Accuracy                           1.00000                    1.00000
##                      Class: Urtica dioica
## Sensitivity                           1.00000
## Specificity                           1.00000
## Pos Pred Value                        1.00000
## Neg Pred Value                        1.00000
## Prevalence                            0.02564
## Detection Rate                        0.02564
```

```
## Detection Prevalence              0.02564
## Balanced Accuracy                 1.00000
```

Let's start prediction and come out with the confusion matrix on test data

```r
#it is in the caret package
prediction2 <- predict(model, test)
#str(train$Species)==str(test$Species)
#confusionMatrix(prediction2,test$Species)
length(prediction2)
```

```
## [1] 106
```

```r
#print(head(test$Species))
confusionMatrix(prediction2,test$Species)
```

```
## Confusion Matrix and Statistics
##
##                          Reference
## Prediction               Acca sellowiana Acer palmatum Alnus sp.
##    Acca sellowiana                     2             0         0
##    Acer palmatum                       0             3         0
##    Alnus sp.                           0             0         0
##    Arisarum vulgare                    0             0         0
##    Betula pubescens                    0             0         1
##    Bougainvillea sp.                   1             0         1
##    Buxus sempervirens                  0             0         0
##    Castanea sativa                     0             0         0
##    Celtis sp.                          0             0         0
##    Corylus avellana                    0             0         0
##    Crataegus monogyna                  0             0         0
##    Erodium sp.                         0             0         0
##    Euonymus japonicus                  0             0         0
##    Geranium sp.                        0             0         0
##    Hydrangea sp.                       0             0         0
##    Ilex aquifolium                     0             0         0
##    Ilex perado ssp. azorica            0             0         0
##    Magnolia grandiflora                0             0         0
##    Magnolia soulangeana                0             0         0
##    Nerium oleander                     0             0         0
##    Podocarpus sp.                      0             0         0
##    Populus alba                        0             0         0
##    Populus nigra                       0             0         0
##    Primula vulgaris                    0             0         0
##    Pseudosasa japonica                 0             0         0
##    Quercus robur                       0             0         0
##    Quercus suber                       0             0         0
##    Salix atrocinera                    0             0         0
##    Tilia tomentosa                     0             0         0
##    Urtica dioica                       0             0         0
##                          Reference
## Prediction               Arisarum vulgare Betula pubescens Bougainvillea sp.
##    Acca sellowiana                      0                0                 0
##    Acer palmatum                        0                0                 0
##    Alnus sp.                            0                0                 0
##    Arisarum vulgare                     1                0                 0
```

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```
##    Betula pubescens               0            2            0
##    Bougainvillea sp.              0            0            5
##    Buxus sempervirens             0            0            0
##    Castanea sativa                0            0            0
##    Celtis sp.                     0            0            0
##    Corylus avellana               0            0            0
##    Crataegus monogyna             0            0            0
##    Erodium sp.                    0            0            0
##    Euonymus japonicus             0            0            0
##    Geranium sp.                   0            0            0
##    Hydrangea sp.                  0            0            0
##    Ilex aquifolium                0            0            0
##    Ilex perado ssp. azorica       0            0            0
##    Magnolia grandiflora           0            0            0
##    Magnolia soulangeana           0            0            0
##    Nerium oleander                0            0            0
##    Podocarpus sp.                 0            0            0
##    Populus alba                   0            0            0
##    Populus nigra                  0            0            0
##    Primula vulgaris               0            0            0
##    Pseudosasa japonica            0            0            0
##    Quercus robur                  0            0            0
##    Quercus suber                  0            0            0
##    Salix atrocinera               0            0            0
##    Tilia tomentosa                0            1            0
##    Urtica dioica                  0            0            0
##                          Reference
## Prediction               Buxus sempervirens Castanea sativa Celtis sp.
##    Acca sellowiana                     0            0            0
##    Acer palmatum                       0            0            0
##    Alnus sp.                           0            0            0
##    Arisarum vulgare                    0            0            0
##    Betula pubescens                    0            0            0
##    Bougainvillea sp.                   0            0            0
##    Buxus sempervirens                  2            0            0
##    Castanea sativa                     0            3            0
##    Celtis sp.                          0            0            5
##    Corylus avellana                    0            0            0
##    Crataegus monogyna                  0            0            0
##    Erodium sp.                         0            0            0
##    Euonymus japonicus                  0            0            0
##    Geranium sp.                        0            0            0
##    Hydrangea sp.                       0            0            0
##    Ilex aquifolium                     0            0            1
##    Ilex perado ssp. azorica            0            0            0
##    Magnolia grandiflora                0            0            0
##    Magnolia soulangeana                0            1            0
##    Nerium oleander                     0            0            0
##    Podocarpus sp.                      0            0            0
##    Populus alba                        0            0            0
##    Populus nigra                       0            0            0
##    Primula vulgaris                    0            0            0
##    Pseudosasa japonica                 0            0            0
##    Quercus robur                       0            0            0
```

```
##    Quercus suber                                0              0             0
##    Salix atrocinera                             0              0             1
##    Tilia tomentosa                              0              0             0
##    Urtica dioica                                0              0             0
##                            Reference
## Prediction                 Corylus avellana Crataegus monogyna Erodium sp.
##    Acca sellowiana                        0                  0           0
##    Acer palmatum                          0                  0           0
##    Alnus sp.                              0                  0           0
##    Arisarum vulgare                       0                  0           0
##    Betula pubescens                       0                  0           0
##    Bougainvillea sp.                      0                  0           0
##    Buxus sempervirens                     0                  0           0
##    Castanea sativa                        0                  0           0
##    Celtis sp.                             0                  0           0
##    Corylus avellana                       4                  0           0
##    Crataegus monogyna                     0                  2           0
##    Erodium sp.                            0                  0           5
##    Euonymus japonicus                     0                  0           0
##    Geranium sp.                           0                  0           0
##    Hydrangea sp.                          2                  0           0
##    Ilex aquifolium                        0                  0           0
##    Ilex perado ssp. azorica               0                  0           0
##    Magnolia grandiflora                   0                  0           0
##    Magnolia soulangeana                   0                  0           0
##    Nerium oleander                        0                  0           0
##    Podocarpus sp.                         0                  0           0
##    Populus alba                           0                  0           0
##    Populus nigra                          0                  0           0
##    Primula vulgaris                       0                  0           0
##    Pseudosasa japonica                    0                  0           0
##    Quercus robur                          0                  0           0
##    Quercus suber                          0                  0           0
##    Salix atrocinera                       0                  0           0
##    Tilia tomentosa                        0                  0           0
##    Urtica dioica                          0                  0           0
##                            Reference
## Prediction                 Euonymus japonicus Geranium sp. Hydrangea sp.
##    Acca sellowiana                          0            0             0
##    Acer palmatum                            0            1             0
##    Alnus sp.                                0            0             0
##    Arisarum vulgare                         0            0             0
##    Betula pubescens                         0            0             0
##    Bougainvillea sp.                        1            0             1
##    Buxus sempervirens                       0            0             0
##    Castanea sativa                          0            0             0
##    Celtis sp.                               0            0             0
##    Corylus avellana                         2            0             0
##    Crataegus monogyna                       0            0             0
##    Erodium sp.                              0            0             0
##    Euonymus japonicus                       0            0             0
##    Geranium sp.                             0            1             0
##    Hydrangea sp.                            0            0             1
##    Ilex aquifolium                          0            0             0
```

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```
##     Ilex perado ssp. azorica                0              0              0
##     Magnolia grandiflora                     0              0              0
##     Magnolia soulangeana                     0              0              0
##     Nerium oleander                          0              0              0
##     Podocarpus sp.                           0              0              0
##     Populus alba                             0              0              0
##     Populus nigra                            0              0              0
##     Primula vulgaris                         0              0              0
##     Pseudosasa japonica                      0              0              0
##     Quercus robur                            0              0              0
##     Quercus suber                            0              0              0
##     Salix atrocinera                         0              0              0
##     Tilia tomentosa                          0              0              0
##     Urtica dioica                            0              0              0
##                           Reference
## Prediction                 Ilex aquifolium Ilex perado ssp. azorica
##     Acca sellowiana                       1                        1
##     Acer palmatum                         0                        0
##     Alnus sp.                             0                        0
##     Arisarum vulgare                      0                        0
##     Betula pubescens                      0                        0
##     Bougainvillea sp.                     0                        0
##     Buxus sempervirens                    0                        0
##     Castanea sativa                       0                        0
##     Celtis sp.                            0                        0
##     Corylus avellana                      0                        0
##     Crataegus monogyna                    0                        0
##     Erodium sp.                           0                        0
##     Euonymus japonicus                    0                        1
##     Geranium sp.                          0                        0
##     Hydrangea sp.                         0                        0
##     Ilex aquifolium                       3                        0
##     Ilex perado ssp. azorica              0                        1
##     Magnolia grandiflora                  0                        0
##     Magnolia soulangeana                  0                        0
##     Nerium oleander                       0                        0
##     Podocarpus sp.                        0                        0
##     Populus alba                          0                        0
##     Populus nigra                         0                        0
##     Primula vulgaris                      0                        0
##     Pseudosasa japonica                   0                        0
##     Quercus robur                         0                        0
##     Quercus suber                         0                        0
##     Salix atrocinera                      0                        0
##     Tilia tomentosa                       0                        0
##     Urtica dioica                         0                        0
##                           Reference
## Prediction                 Magnolia grandiflora Magnolia soulangeana
##     Acca sellowiana                          0                    0
##     Acer palmatum                            0                    0
##     Alnus sp.                                0                    0
##     Arisarum vulgare                         0                    0
##     Betula pubescens                         0                    0
##     Bougainvillea sp.                        0                    0
```

```
##    Buxus sempervirens                0              0
##    Castanea sativa                   0              0
##    Celtis sp.                        0              0
##    Corylus avellana                  0              0
##    Crataegus monogyna                0              0
##    Erodium sp.                       0              0
##    Euonymus japonicus                0              0
##    Geranium sp.                      0              0
##    Hydrangea sp.                     0              0
##    Ilex aquifolium                   0              0
##    Ilex perado ssp. azorica          0              0
##    Magnolia grandiflora              2              0
##    Magnolia soulangeana              2              1
##    Nerium oleander                   0              0
##    Podocarpus sp.                    0              0
##    Populus alba                      0              0
##    Populus nigra                     0              0
##    Primula vulgaris                  1              0
##    Pseudosasa japonica               0              0
##    Quercus robur                     0              0
##    Quercus suber                     0              0
##    Salix atrocinera                  0              0
##    Tilia tomentosa                   0              0
##    Urtica dioica                     0              0
##                             Reference
## Prediction                  Nerium oleander Podocarpus sp. Populus alba
##    Acca sellowiana                        0              0            0
##    Acer palmatum                          0              0            0
##    Alnus sp.                              0              0            0
##    Arisarum vulgare                       0              0            0
##    Betula pubescens                       0              0            0
##    Bougainvillea sp.                      0              0            0
##    Buxus sempervirens                     0              0            0
##    Castanea sativa                        0              0            0
##    Celtis sp.                             0              0            0
##    Corylus avellana                       0              0            0
##    Crataegus monogyna                     0              0            0
##    Erodium sp.                            0              0            0
##    Euonymus japonicus                     0              0            0
##    Geranium sp.                           0              0            0
##    Hydrangea sp.                          0              0            0
##    Ilex aquifolium                        0              0            0
##    Ilex perado ssp. azorica               0              0            0
##    Magnolia grandiflora                   0              0            0
##    Magnolia soulangeana                   0              0            0
##    Nerium oleander                        1              0            0
##    Podocarpus sp.                         0              1            0
##    Populus alba                           0              0            1
##    Populus nigra                          0              0            0
##    Primula vulgaris                       0              0            0
##    Pseudosasa japonica                    0              0            0
##    Quercus robur                          0              0            0
##    Quercus suber                          0              0            0
##    Salix atrocinera                       0              0            0
```

```
##    Tilia tomentosa                   0              0             0
##    Urtica dioica                     0              0             0
##                            Reference
## Prediction                 Populus nigra Primula vulgaris Pseudosasa japonica
##    Acca sellowiana                     0               1                   0
##    Acer palmatum                       0               0                   0
##    Alnus sp.                           0               0                   0
##    Arisarum vulgare                    1               0                   0
##    Betula pubescens                    1               0                   0
##    Bougainvillea sp.                   0               0                   0
##    Buxus sempervirens                  0               0                   0
##    Castanea sativa                     0               0                   0
##    Celtis sp.                          0               0                   0
##    Corylus avellana                    0               0                   0
##    Crataegus monogyna                  0               1                   0
##    Erodium sp.                         1               0                   0
##    Euonymus japonicus                  0               0                   0
##    Geranium sp.                        0               0                   0
##    Hydrangea sp.                       0               0                   0
##    Ilex aquifolium                     0               1                   0
##    Ilex perado ssp. azorica            0               0                   0
##    Magnolia grandiflora                0               0                   0
##    Magnolia soulangeana                0               0                   0
##    Nerium oleander                     0               0                   0
##    Podocarpus sp.                      0               0                   2
##    Populus alba                        0               0                   0
##    Populus nigra                       3               0                   0
##    Primula vulgaris                    0               2                   0
##    Pseudosasa japonica                 0               0                   1
##    Quercus robur                       0               0                   0
##    Quercus suber                       0               0                   0
##    Salix atrocinera                    0               0                   0
##    Tilia tomentosa                     0               0                   0
##    Urtica dioica                       0               0                   0
##                            Reference
## Prediction                 Quercus robur Quercus suber Salix atrocinera
##    Acca sellowiana                     0             0                1
##    Acer palmatum                       0             0                0
##    Alnus sp.                           0             0                0
##    Arisarum vulgare                    0             0                0
##    Betula pubescens                    0             0                0
##    Bougainvillea sp.                   0             0                0
##    Buxus sempervirens                  0             1                0
##    Castanea sativa                     0             0                0
##    Celtis sp.                          0             0                0
##    Corylus avellana                    0             1                0
##    Crataegus monogyna                  0             0                0
##    Erodium sp.                         0             0                0
##    Euonymus japonicus                  0             0                0
##    Geranium sp.                        0             0                0
##    Hydrangea sp.                       0             0                0
##    Ilex aquifolium                     0             0                0
##    Ilex perado ssp. azorica            0             0                0
##    Magnolia grandiflora                0             0                0
```

```
##    Magnolia soulangeana                    0            0            0
##    Nerium oleander                         0            0            0
##    Podocarpus sp.                          0            0            0
##    Populus alba                            0            0            0
##    Populus nigra                           0            0            0
##    Primula vulgaris                        0            0            0
##    Pseudosasa japonica                     0            0            0
##    Quercus robur                           4            0            0
##    Quercus suber                           0            4            0
##    Salix atrocinera                        0            0            3
##    Tilia tomentosa                         0            0            0
##    Urtica dioica                           0            0            0
##                              Reference
## Prediction              Tilia tomentosa Urtica dioica
##    Acca sellowiana                     0             0
##    Acer palmatum                       0             0
##    Alnus sp.                           0             0
##    Arisarum vulgare                    0             0
##    Betula pubescens                    0             0
##    Bougainvillea sp.                   0             0
##    Buxus sempervirens                  0             0
##    Castanea sativa                     0             0
##    Celtis sp.                          0             0
##    Corylus avellana                    0             0
##    Crataegus monogyna                  0             0
##    Erodium sp.                         0             0
##    Euonymus japonicus                  0             0
##    Geranium sp.                        0             0
##    Hydrangea sp.                       0             0
##    Ilex aquifolium                     0             0
##    Ilex perado ssp. azorica            0             0
##    Magnolia grandiflora                0             0
##    Magnolia soulangeana                0             0
##    Nerium oleander                     0             0
##    Podocarpus sp.                      0             0
##    Populus alba                        0             0
##    Populus nigra                       0             0
##    Primula vulgaris                    0             0
##    Pseudosasa japonica                 0             0
##    Quercus robur                       0             0
##    Quercus suber                       0             0
##    Salix atrocinera                    0             0
##    Tilia tomentosa                     6             0
##    Urtica dioica                       0             6
##
## Overall Statistics
##
##                Accuracy : 0.7075
##                  95% CI : (0.6113, 0.7919)
##     No Information Rate : 0.066
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.6955
##
```

```
##   Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Acca sellowiana Class: Acer palmatum
## Sensitivity                        0.66667              1.00000
## Specificity                        0.96117              0.99029
## Pos Pred Value                     0.33333              0.75000
## Neg Pred Value                     0.99000              1.00000
## Prevalence                         0.02830              0.02830
## Detection Rate                     0.01887              0.02830
## Detection Prevalence               0.05660              0.03774
## Balanced Accuracy                  0.81392              0.99515
##                      Class: Alnus sp. Class: Arisarum vulgare
## Sensitivity                  0.00000                1.000000
## Specificity                  1.00000                0.990476
## Pos Pred Value                   NaN                0.500000
## Neg Pred Value               0.98113                1.000000
## Prevalence                   0.01887                0.009434
## Detection Rate               0.00000                0.009434
## Detection Prevalence         0.00000                0.018868
## Balanced Accuracy            0.50000                0.995238
##                      Class: Betula pubescens Class: Bougainvillea sp.
## Sensitivity                         0.66667                  1.00000
## Specificity                         0.98058                  0.96040
## Pos Pred Value                      0.50000                  0.55556
## Neg Pred Value                      0.99020                  1.00000
## Prevalence                          0.02830                  0.04717
## Detection Rate                      0.01887                  0.04717
## Detection Prevalence                0.03774                  0.08491
## Balanced Accuracy                   0.82362                  0.98020
##                      Class: Buxus sempervirens Class: Castanea sativa
## Sensitivity                          1.00000                0.75000
## Specificity                          0.99038                1.00000
## Pos Pred Value                       0.66667                1.00000
## Neg Pred Value                       1.00000                0.99029
## Prevalence                           0.01887                0.03774
## Detection Rate                       0.01887                0.02830
## Detection Prevalence                 0.02830                0.02830
## Balanced Accuracy                    0.99519                0.87500
##                      Class: Celtis sp. Class: Corylus avellana
## Sensitivity                   0.71429                 0.66667
## Specificity                   1.00000                 0.97000
## Pos Pred Value                1.00000                 0.57143
## Neg Pred Value                0.98020                 0.97980
## Prevalence                    0.06604                 0.05660
## Detection Rate                0.04717                 0.03774
## Detection Prevalence          0.04717                 0.06604
## Balanced Accuracy             0.85714                 0.81833
##                      Class: Crataegus monogyna Class: Erodium sp.
## Sensitivity                          1.00000             1.00000
## Specificity                          0.99038             0.99010
## Pos Pred Value                       0.66667             0.83333
## Neg Pred Value                       1.00000             1.00000
```

```
## Prevalence                              0.01887               0.04717
## Detection Rate                          0.01887               0.04717
## Detection Prevalence                    0.02830               0.05660
## Balanced Accuracy                       0.99519               0.99505
##                      Class: Euonymus japonicus Class: Geranium sp.
## Sensitivity                            0.000000              0.500000
## Specificity                            0.990291              1.000000
## Pos Pred Value                         0.000000              1.000000
## Neg Pred Value                         0.971429              0.990476
## Prevalence                             0.028302              0.018868
## Detection Rate                         0.000000              0.009434
## Detection Prevalence                   0.009434              0.009434
## Balanced Accuracy                      0.495146              0.750000
##                         Class: Hydrangea sp. Class: Ilex aquifolium
## Sensitivity                          0.500000               0.75000
## Specificity                          0.980769               0.98039
## Pos Pred Value                       0.333333               0.60000
## Neg Pred Value                       0.990291               0.99010
## Prevalence                           0.018868               0.03774
## Detection Rate                       0.009434               0.02830
## Detection Prevalence                 0.028302               0.04717
## Balanced Accuracy                    0.740385               0.86520
##                      Class: Ilex perado ssp. azorica
## Sensitivity                                  0.333333
## Specificity                                  1.000000
## Pos Pred Value                               1.000000
## Neg Pred Value                               0.980952
## Prevalence                                   0.028302
## Detection Rate                               0.009434
## Detection Prevalence                         0.009434
## Balanced Accuracy                            0.666667
##                      Class: Magnolia grandiflora Class: Magnolia soulangeana
## Sensitivity                             0.40000                    1.000000
## Specificity                             1.00000                    0.971429
## Pos Pred Value                          1.00000                    0.250000
## Neg Pred Value                          0.97115                    1.000000
## Prevalence                              0.04717                    0.009434
## Detection Rate                          0.01887                    0.009434
## Detection Prevalence                    0.01887                    0.037736
## Balanced Accuracy                       0.70000                    0.985714
##                      Class: Nerium oleander Class: Podocarpus sp.
## Sensitivity                          1.000000              1.000000
## Specificity                          1.000000              0.980952
## Pos Pred Value                       1.000000              0.333333
## Neg Pred Value                       1.000000              1.000000
## Prevalence                           0.009434              0.009434
## Detection Rate                       0.009434              0.009434
## Detection Prevalence                 0.009434              0.028302
## Balanced Accuracy                    1.000000              0.990476
##                      Class: Populus alba Class: Populus nigra
## Sensitivity                       1.000000               0.5000
## Specificity                       1.000000               1.0000
## Pos Pred Value                    1.000000               1.0000
## Neg Pred Value                    1.000000               0.9709
```

```
## Prevalence                         0.009434                0.0566
## Detection Rate                      0.009434                0.0283
## Detection Prevalence                0.009434                0.0283
## Balanced Accuracy                   1.000000                0.7500
##                      Class: Primula vulgaris Class: Pseudosasa japonica
## Sensitivity                         0.40000                   0.333333
## Specificity                         0.99010                   1.000000
## Pos Pred Value                      0.66667                   1.000000
## Neg Pred Value                      0.97087                   0.980952
## Prevalence                          0.04717                   0.028302
## Detection Rate                      0.01887                   0.009434
## Detection Prevalence                0.02830                   0.009434
## Balanced Accuracy                   0.69505                   0.666667
##                      Class: Quercus robur Class: Quercus suber
## Sensitivity                       1.00000              0.66667
## Specificity                       1.00000              1.00000
## Pos Pred Value                    1.00000              1.00000
## Neg Pred Value                    1.00000              0.98039
## Prevalence                        0.03774              0.05660
## Detection Rate                    0.03774              0.03774
## Detection Prevalence              0.03774              0.03774
## Balanced Accuracy                 1.00000              0.83333
##                      Class: Salix atrocinera Class: Tilia tomentosa
## Sensitivity                         0.75000                1.00000
## Specificity                         0.99020                0.99000
## Pos Pred Value                      0.75000                0.85714
## Neg Pred Value                      0.99020                1.00000
## Prevalence                          0.03774                0.05660
## Detection Rate                      0.02830                0.05660
## Detection Prevalence                0.03774                0.06604
## Balanced Accuracy                   0.87010                0.99500
##                      Class: Urtica dioica
## Sensitivity                       1.0000
## Specificity                       1.0000
## Pos Pred Value                    1.0000
## Neg Pred Value                    1.0000
## Prevalence                        0.0566
## Detection Rate                    0.0566
## Detection Prevalence              0.0566
## Balanced Accuracy                 1.0000
```
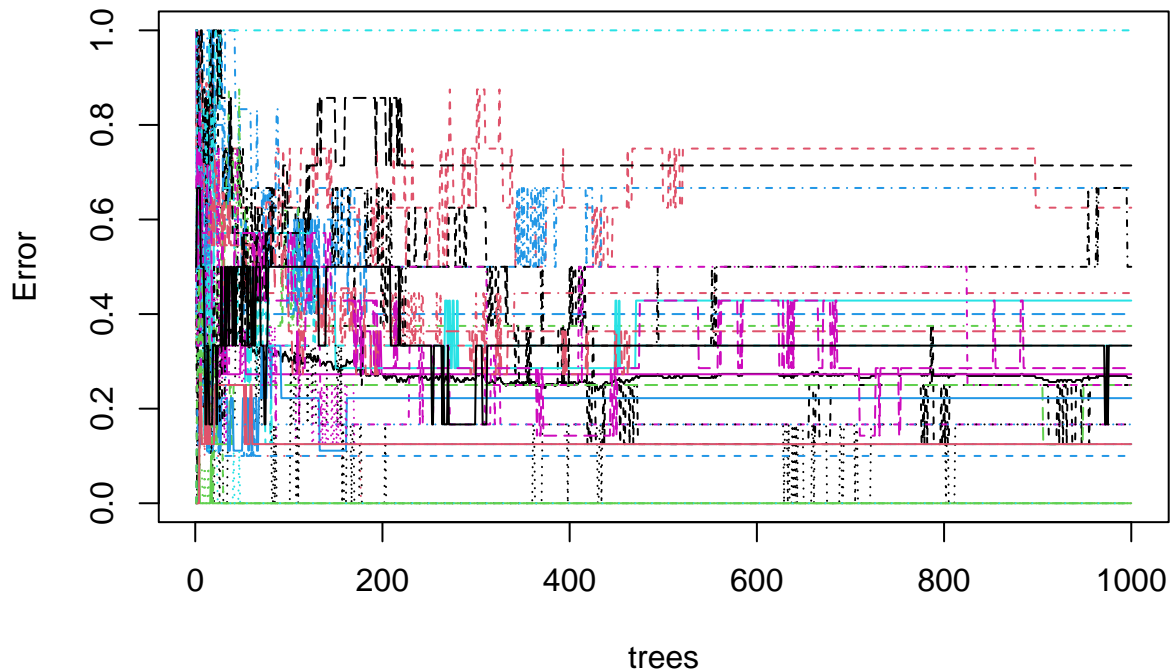
```
#length(test$Species)
```

let's find the error rate

```
plot(model)
```

model


```
model
```

```
##
## Call:
##  randomForest(formula = Species ~ ., data = train, ntree = 1000)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 3
##
##          OOB estimate of  error rate: 26.5%
## Confusion matrix:
##                       Acca sellowiana Acer palmatum Alnus sp.
## Acca sellowiana                     3             0         0
## Acer palmatum                       0            13         0
## Alnus sp.                           0             0         2
## Arisarum vulgare                    0             0         0
## Betula pubescens                    0             0         0
## Bougainvillea sp.                   0             0         0
## Buxus sempervirens                  0             0         0
## Castanea sativa                     1             0         0
## Celtis sp.                          0             0         0
## Corylus avellana                    0             0         0
## Crataegus monogyna                  0             1         0
## Erodium sp.                         0             0         0
## Euonymus japonicus                  1             0         0
## Geranium sp.                        0             1         0
## Hydrangea sp.                       0             0         0
## Ilex aquifolium                     0             0         0
## Ilex perado ssp. azorica            0             0         0
## Magnolia grandiflora                0             0         0
```

```
## Magnolia soulangeana                       0               0            0
## Nerium oleander                            0               0            0
## Podocarpus sp.                             0               0            0
## Populus alba                               0               0            0
## Populus nigra                              0               0            0
## Primula vulgaris                           0               0            0
## Pseudosasa japonica                        0               0            0
## Quercus robur                              0               0            0
## Quercus suber                              0               0            0
## Salix atrocinera                           6               0            0
## Tilia tomentosa                            0               0            0
## Urtica dioica                              0               0            0
##                            Arisarum vulgare Betula pubescens Bougainvillea sp.
## Acca sellowiana                           0               0                 0
## Acer palmatum                             0               0                 0
## Alnus sp.                                 0               1                 1
## Arisarum vulgare                          7               0                 0
## Betula pubescens                          0               8                 0
## Bougainvillea sp.                         0               1                 6
## Buxus sempervirens                        0               0                 0
## Castanea sativa                           0               0                 0
## Celtis sp.                                0               0                 0
## Corylus avellana                          0               0                 0
## Crataegus monogyna                        0               0                 0
## Erodium sp.                               0               0                 0
## Euonymus japonicus                        0               0                 0
## Geranium sp.                              0               0                 0
## Hydrangea sp.                             0               0                 0
## Ilex aquifolium                           0               0                 0
## Ilex perado ssp. azorica                  0               0                 1
## Magnolia grandiflora                      0               0                 0
## Magnolia soulangeana                      0               0                 0
## Nerium oleander                           0               0                 0
## Podocarpus sp.                            0               0                 0
## Populus alba                              0               0                 0
## Populus nigra                             0               1                 0
## Primula vulgaris                          0               0                 0
## Pseudosasa japonica                       0               0                 0
## Quercus robur                             0               0                 0
## Quercus suber                             0               0                 0
## Salix atrocinera                          0               0                 0
## Tilia tomentosa                           1               1                 0
## Urtica dioica                             0               2                 0
##                            Buxus sempervirens Castanea sativa Celtis sp.
## Acca sellowiana                            0               1          0
## Acer palmatum                              0               0          0
## Alnus sp.                                  0               0          0
## Arisarum vulgare                           0               0          0
## Betula pubescens                           0               0          0
## Bougainvillea sp.                          0               0          0
## Buxus sempervirens                        10               0          0
## Castanea sativa                            0               5          0
## Celtis sp.                                 0               0          3
## Corylus avellana                           0               0          0
```

```
## Crataegus monogyna                                0              0            0
## Erodium sp.                                        1              0            0
## Euonymus japonicus                                 0              0            0
## Geranium sp.                                       0              0            0
## Hydrangea sp.                                      0              0            0
## Ilex aquifolium                                    0              0            1
## Ilex perado ssp. azorica                           0              0            0
## Magnolia grandiflora                               0              0            0
## Magnolia soulangeana                               0              1            0
## Nerium oleander                                    0              0            0
## Podocarpus sp.                                     0              0            0
## Populus alba                                       0              0            0
## Populus nigra                                      0              0            0
## Primula vulgaris                                   0              1            1
## Pseudosasa japonica                                0              0            0
## Quercus robur                                      0              0            0
## Quercus suber                                      0              0            0
## Salix atrocinera                                   0              0            0
## Tilia tomentosa                                    0              0            0
## Urtica dioica                                      0              0            0
##                       Corylus avellana Crataegus monogyna Erodium sp.
## Acca sellowiana                      0                  0           0
## Acer palmatum                        0                  0           0
## Alnus sp.                            0                  0           0
## Arisarum vulgare                     0                  0           0
## Betula pubescens                     0                  0           1
## Bougainvillea sp.                    0                  0           0
## Buxus sempervirens                   0                  0           0
## Castanea sativa                      0                  0           0
## Celtis sp.                           0                  0           0
## Corylus avellana                     4                  0           0
## Crataegus monogyna                   0                  5           0
## Erodium sp.                          0                  0           5
## Euonymus japonicus                   1                  0           0
## Geranium sp.                         0                  0           0
## Hydrangea sp.                        1                  0           0
## Ilex aquifolium                      0                  0           0
## Ilex perado ssp. azorica             0                  0           0
## Magnolia grandiflora                 0                  0           0
## Magnolia soulangeana                 0                  0           0
## Nerium oleander                      0                  0           0
## Podocarpus sp.                       0                  0           0
## Populus alba                         0                  0           0
## Populus nigra                        0                  0           0
## Primula vulgaris                     0                  0           0
## Pseudosasa japonica                  0                  0           0
## Quercus robur                        0                  0           0
## Quercus suber                        0                  0           0
## Salix atrocinera                     0                  0           0
## Tilia tomentosa                      0                  0           0
## Urtica dioica                        0                  0           0
##                       Euonymus japonicus Geranium sp. Hydrangea sp.
## Acca sellowiana                        0            0             0
## Acer palmatum                          0            0             0
```

```
## Alnus sp.                              2              0              0
## Arisarum vulgare                       0              0              0
## Betula pubescens                       0              0              0
## Bougainvillea sp.                      0              0              0
## Buxus sempervirens                     0              0              0
## Castanea sativa                        0              0              0
## Celtis sp.                             0              0              0
## Corylus avellana                       1              0              1
## Crataegus monogyna                     0              0              0
## Erodium sp.                            0              0              0
## Euonymus japonicus                     5              0              1
## Geranium sp.                           0              6              0
## Hydrangea sp.                          0              0              7
## Ilex aquifolium                        0              0              0
## Ilex perado ssp. azorica               0              0              0
## Magnolia grandiflora                   0              0              0
## Magnolia soulangeana                   0              0              0
## Nerium oleander                        0              0              0
## Podocarpus sp.                         0              0              0
## Populus alba                           0              0              0
## Populus nigra                          0              0              0
## Primula vulgaris                       0              0              0
## Pseudosasa japonica                    0              0              0
## Quercus robur                          0              0              0
## Quercus suber                          0              0              0
## Salix atrocinera                       0              0              0
## Tilia tomentosa                        0              0              0
## Urtica dioica                          0              0              0
##                          Ilex aquifolium Ilex perado ssp. azorica
## Acca sellowiana                        0                        1
## Acer palmatum                          0                        0
## Alnus sp.                              0                        0
## Arisarum vulgare                       0                        0
## Betula pubescens                       1                        0
## Bougainvillea sp.                      0                        0
## Buxus sempervirens                     0                        0
## Castanea sativa                        0                        0
## Celtis sp.                             0                        0
## Corylus avellana                       0                        1
## Crataegus monogyna                     0                        0
## Erodium sp.                            0                        0
## Euonymus japonicus                     1                        0
## Geranium sp.                           0                        0
## Hydrangea sp.                          0                        0
## Ilex aquifolium                        4                        0
## Ilex perado ssp. azorica               0                        7
## Magnolia grandiflora                   0                        0
## Magnolia soulangeana                   0                        0
## Nerium oleander                        0                        0
## Podocarpus sp.                         0                        0
## Populus alba                           0                        0
## Populus nigra                          0                        0
## Primula vulgaris                       1                        0
## Pseudosasa japonica                    0                        0
```

```
## Quercus robur                                   0                        0
## Quercus suber                                    0                        1
## Salix atrocinera                                 0                        0
## Tilia tomentosa                                  0                        0
## Urtica dioica                                    0                        0
##                            Magnolia grandiflora Magnolia soulangeana
## Acca sellowiana                                  0                        0
## Acer palmatum                                    0                        0
## Alnus sp.                                        0                        0
## Arisarum vulgare                                 0                        0
## Betula pubescens                                 0                        0
## Bougainvillea sp.                                0                        0
## Buxus sempervirens                               0                        0
## Castanea sativa                                  0                        1
## Celtis sp.                                       0                        1
## Corylus avellana                                 0                        0
## Crataegus monogyna                               0                        0
## Erodium sp.                                      0                        0
## Euonymus japonicus                               0                        0
## Geranium sp.                                     0                        0
## Hydrangea sp.                                    0                        0
## Ilex aquifolium                                  0                        0
## Ilex perado ssp. azorica                         0                        0
## Magnolia grandiflora                             3                        3
## Magnolia soulangeana                             3                        7
## Nerium oleander                                  0                        0
## Podocarpus sp.                                   0                        0
## Populus alba                                     0                        0
## Populus nigra                                    0                        0
## Primula vulgaris                                 0                        1
## Pseudosasa japonica                              0                        0
## Quercus robur                                    0                        0
## Quercus suber                                    0                        0
## Salix atrocinera                                 0                        0
## Tilia tomentosa                                  0                        0
## Urtica dioica                                    0                        0
##                            Nerium oleander Podocarpus sp. Populus alba
## Acca sellowiana                          0              0            0
## Acer palmatum                            0              0            0
## Alnus sp.                                0              0            0
## Arisarum vulgare                         0              0            0
## Betula pubescens                         0              0            0
## Bougainvillea sp.                        0              0            0
## Buxus sempervirens                       0              0            0
## Castanea sativa                          0              0            0
## Celtis sp.                               0              0            0
## Corylus avellana                         0              0            0
## Crataegus monogyna                       0              0            0
## Erodium sp.                              0              0            0
## Euonymus japonicus                       0              0            0
## Geranium sp.                             0              0            1
## Hydrangea sp.                            0              0            0
## Ilex aquifolium                          0              0            0
## Ilex perado ssp. azorica                 0              0            0
```

```
## Magnolia grandiflora                      0              0              0
## Magnolia soulangeana                      0              0              0
## Nerium oleander                          10              0              0
## Podocarpus sp.                            0              9              0
## Populus alba                              0              0              9
## Populus nigra                             0              0              0
## Primula vulgaris                          0              0              0
## Pseudosasa japonica                       0              1              0
## Quercus robur                             0              0              0
## Quercus suber                             0              0              0
## Salix atrocinera                          0              0              0
## Tilia tomentosa                           0              0              0
## Urtica dioica                             0              0              0
##                          Populus nigra Primula vulgaris Pseudosasa japonica
## Acca sellowiana                      0                0                   0
## Acer palmatum                        0                0                   0
## Alnus sp.                            0                0                   0
## Arisarum vulgare                     0                0                   0
## Betula pubescens                     0                0                   0
## Bougainvillea sp.                    0                0                   0
## Buxus sempervirens                   0                0                   0
## Castanea sativa                      0                1                   0
## Celtis sp.                           0                1                   0
## Corylus avellana                     0                0                   0
## Crataegus monogyna                   0                0                   0
## Erodium sp.                          0                0                   0
## Euonymus japonicus                   0                0                   0
## Geranium sp.                         0                0                   0
## Hydrangea sp.                        0                0                   0
## Ilex aquifolium                      0                0                   0
## Ilex perado ssp. azorica             0                0                   0
## Magnolia grandiflora                 0                0                   0
## Magnolia soulangeana                 0                0                   0
## Nerium oleander                      0                0                   0
## Podocarpus sp.                       0                0                   1
## Populus alba                         0                0                   0
## Populus nigra                        3                0                   0
## Primula vulgaris                     0                2                   0
## Pseudosasa japonica                  0                0                   7
## Quercus robur                        0                0                   0
## Quercus suber                        0                0                   0
## Salix atrocinera                     0                0                   0
## Tilia tomentosa                      0                0                   0
## Urtica dioica                        0                0                   0
##                          Quercus robur Quercus suber Salix atrocinera
## Acca sellowiana                      0             0                3
## Acer palmatum                        0             0                0
## Alnus sp.                            0             0                0
## Arisarum vulgare                     0             0                0
## Betula pubescens                     0             0                0
## Bougainvillea sp.                    0             1                0
## Buxus sempervirens                   0             0                0
## Castanea sativa                      0             0                0
## Celtis sp.                           0             0                0
```

```
## Corylus avellana                   0                0                0
## Crataegus monogyna                 0                0                0
## Erodium sp.                        0                0                0
## Euonymus japonicus                 0                0                0
## Geranium sp.                       0                0                0
## Hydrangea sp.                      0                1                0
## Ilex aquifolium                    1                0                0
## Ilex perado ssp. azorica           0                0                0
## Magnolia grandiflora               0                0                0
## Magnolia soulangeana               0                0                0
## Nerium oleander                    0                0                0
## Podocarpus sp.                     0                0                0
## Populus alba                       0                0                0
## Populus nigra                      0                0                0
## Primula vulgaris                   1                0                0
## Pseudosasa japonica                0                0                0
## Quercus robur                      8                0                0
## Quercus suber                      0                5                0
## Salix atrocinera                   0                0                0
## Tilia tomentosa                    0                0                0
## Urtica dioica                      0                0                0
##                         Tilia tomentosa Urtica dioica class.error
## Acca sellowiana                       0             0   0.6250000
## Acer palmatum                         0             0   0.0000000
## Alnus sp.                             0             0   0.6666667
## Arisarum vulgare                      1             0   0.1250000
## Betula pubescens                      1             0   0.2727273
## Bougainvillea sp.                     0             0   0.2500000
## Buxus sempervirens                    0             0   0.0000000
## Castanea sativa                       0             0   0.3750000
## Celtis sp.                            0             0   0.4000000
## Corylus avellana                      0             0   0.4285714
## Crataegus monogyna                    0             0   0.1666667
## Erodium sp.                           0             0   0.1666667
## Euonymus japonicus                    0             0   0.4444444
## Geranium sp.                          0             0   0.2500000
## Hydrangea sp.                         0             0   0.2222222
## Ilex aquifolium                       0             0   0.3333333
## Ilex perado ssp. azorica              0             0   0.1250000
## Magnolia grandiflora                  0             0   0.5000000
## Magnolia soulangeana                  0             0   0.3636364
## Nerium oleander                       0             0   0.0000000
## Podocarpus sp.                        0             0   0.1000000
## Populus alba                          0             0   0.0000000
## Populus nigra                         0             0   0.2500000
## Primula vulgaris                      0             0   0.7142857
## Pseudosasa japonica                   0             0   0.1250000
## Quercus robur                         0             0   0.0000000
## Quercus suber                         0             0   0.1666667
## Salix atrocinera                      0             0   1.0000000
## Tilia tomentosa                       5             0   0.2857143
## Urtica dioica                         0             4   0.3333333
```

```
#tuning mtry
tuneRF(train[,-1], train[,1], stepFactor=0.5, plot=TRUE )
```

```
## mtry = 3  OOB error = 35.04%
## Searching left ...
## mtry = 6     OOB error = 31.62%
## 0.09756098 0.05
## mtry = 12    OOB error = 28.21%
## 0.1081081 0.05
```

```
## Warning in randomForest.default(x, y, mtry = mtryCur, ntree = ntreeTry, :
## invalid mtry: reset to within valid range
```

```
## mtry = 24    OOB error = 27.35%
## 0.03030303 0.05
## Searching right ...
## mtry = 1     OOB error = 38.03%
## -0.3484848 0.05
```
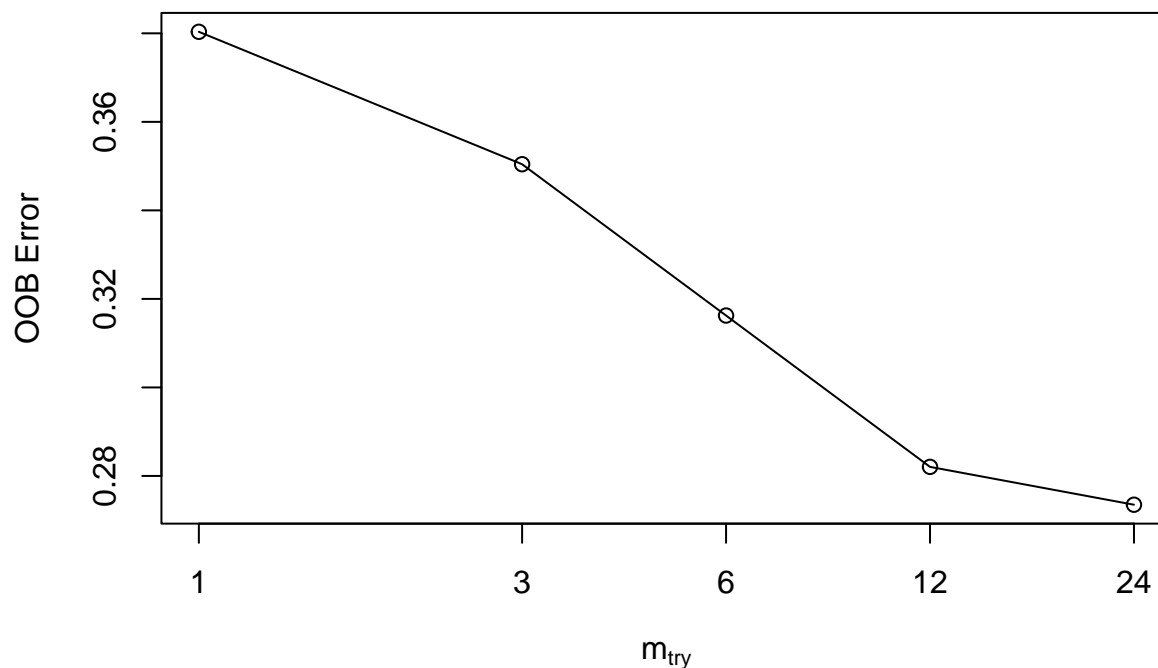


```
##        mtry  OOBError
## 1.00B     1 0.3803419
## 3.00B     3 0.3504274
## 6.00B     6 0.3162393
## 12.00B   12 0.2820513
## 24.00B   24 0.2735043
```

```
set.seed(12345)
model <- randomForest(Species ~ ., data=train, ntree=200, mtry=9, importance=TRUE, proximity=TRUE)
model
```

```
##
## Call:
##  randomForest(formula = Species ~ ., data = train, ntree = 200,     mtry = 9, importance = TRUE, pr
##                 Type of random forest: classification
##                       Number of trees: 200
```

```
## No. of variables tried at each split: 9
##
##         OOB estimate of  error rate: 23.5%
## Confusion matrix:
##                         Acca sellowiana Acer palmatum Alnus sp.
## Acca sellowiana                       5             0         0
## Acer palmatum                         0            13         0
## Alnus sp.                             0             0         3
## Arisarum vulgare                      0             0         0
## Betula pubescens                      0             0         0
## Bougainvillea sp.                     0             0         0
## Buxus sempervirens                    0             0         0
## Castanea sativa                       1             0         0
## Celtis sp.                            0             0         0
## Corylus avellana                      0             0         0
## Crataegus monogyna                    0             0         0
## Erodium sp.                           0             0         0
## Euonymus japonicus                    0             0         0
## Geranium sp.                          0             1         0
## Hydrangea sp.                         0             0         0
## Ilex aquifolium                       0             0         0
## Ilex perado ssp. azorica              0             0         0
## Magnolia grandiflora                  0             0         0
## Magnolia soulangeana                  0             0         0
## Nerium oleander                       0             0         0
## Podocarpus sp.                        0             0         0
## Populus alba                          0             0         0
## Populus nigra                         0             0         0
## Primula vulgaris                      0             0         0
## Pseudosasa japonica                   0             0         0
## Quercus robur                         0             0         0
## Quercus suber                         0             0         0
## Salix atrocinera                      4             0         0
## Tilia tomentosa                       0             0         0
## Urtica dioica                         0             0         0
##                         Arisarum vulgare Betula pubescens Bougainvillea sp.
## Acca sellowiana                        0                0                 0
## Acer palmatum                          0                0                 0
## Alnus sp.                              0                1                 0
## Arisarum vulgare                       7                0                 0
## Betula pubescens                       0                8                 0
## Bougainvillea sp.                      0                0                 7
## Buxus sempervirens                     0                0                 0
## Castanea sativa                        0                0                 0
## Celtis sp.                             0                0                 0
## Corylus avellana                       0                0                 0
## Crataegus monogyna                     0                0                 0
## Erodium sp.                            0                0                 0
## Euonymus japonicus                     0                0                 0
## Geranium sp.                           0                0                 0
## Hydrangea sp.                          0                0                 0
## Ilex aquifolium                        0                0                 0
## Ilex perado ssp. azorica               0                0                 1
## Magnolia grandiflora                   0                0                 0
```

```
## Magnolia soulangeana                            0              0              0
## Nerium oleander                                 0              0              0
## Podocarpus sp.                                  0              0              0
## Populus alba                                    0              0              0
## Populus nigra                                   0              2              0
## Primula vulgaris                                0              0              0
## Pseudosasa japonica                             0              0              0
## Quercus robur                                   0              0              0
## Quercus suber                                   0              0              0
## Salix atrocinera                                0              0              0
## Tilia tomentosa                                 1              1              0
## Urtica dioica                                   0              1              0
##                           Buxus sempervirens Castanea sativa Celtis sp.
## Acca sellowiana                            0              0          0
## Acer palmatum                              0              0          0
## Alnus sp.                                  0              0          0
## Arisarum vulgare                           0              0          0
## Betula pubescens                           0              0          0
## Bougainvillea sp.                          0              0          0
## Buxus sempervirens                         9              0          0
## Castanea sativa                            0              5          0
## Celtis sp.                                 0              0          3
## Corylus avellana                           0              0          0
## Crataegus monogyna                         0              0          0
## Erodium sp.                                0              0          0
## Euonymus japonicus                         0              0          0
## Geranium sp.                               0              0          0
## Hydrangea sp.                              0              0          0
## Ilex aquifolium                            0              0          1
## Ilex perado ssp. azorica                   0              0          0
## Magnolia grandiflora                       0              0          0
## Magnolia soulangeana                       0              1          0
## Nerium oleander                            0              0          0
## Podocarpus sp.                             0              0          0
## Populus alba                               0              0          0
## Populus nigra                              0              0          0
## Primula vulgaris                           0              1          1
## Pseudosasa japonica                        0              0          0
## Quercus robur                              0              0          0
## Quercus suber                              0              0          0
## Salix atrocinera                           0              0          0
## Tilia tomentosa                            0              0          0
## Urtica dioica                              0              0          0
##                           Corylus avellana Crataegus monogyna Erodium sp.
## Acca sellowiana                          0                  0           0
## Acer palmatum                            0                  0           0
## Alnus sp.                                0                  0           0
## Arisarum vulgare                         0                  0           0
## Betula pubescens                         0                  0           1
## Bougainvillea sp.                        0                  0           0
## Buxus sempervirens                       0                  0           1
## Castanea sativa                          0                  0           0
## Celtis sp.                               0                  0           0
## Corylus avellana                         4                  0           0
```

```
## Crataegus monogyna                   0                  5            1
## Erodium sp.                          0                  0            5
## Euonymus japonicus                   0                  0            0
## Geranium sp.                         0                  0            0
## Hydrangea sp.                        1                  0            0
## Ilex aquifolium                      0                  0            0
## Ilex perado ssp. azorica             1                  0            0
## Magnolia grandiflora                 0                  0            0
## Magnolia soulangeana                 0                  0            0
## Nerium oleander                      0                  0            0
## Podocarpus sp.                       0                  0            0
## Populus alba                         0                  0            0
## Populus nigra                        0                  0            0
## Primula vulgaris                     0                  0            0
## Pseudosasa japonica                  0                  0            0
## Quercus robur                        0                  0            0
## Quercus suber                        1                  0            0
## Salix atrocinera                     0                  0            0
## Tilia tomentosa                      0                  0            0
## Urtica dioica                        0                  0            0
##                      Euonymus japonicus Geranium sp. Hydrangea sp.
## Acca sellowiana                       0            0             0
## Acer palmatum                         0            0             0
## Alnus sp.                             1            0             1
## Arisarum vulgare                      0            0             0
## Betula pubescens                      0            0             0
## Bougainvillea sp.                     0            0             0
## Buxus sempervirens                    0            0             0
## Castanea sativa                       0            0             0
## Celtis sp.                            0            0             0
## Corylus avellana                      1            0             1
## Crataegus monogyna                    0            0             0
## Erodium sp.                           0            0             0
## Euonymus japonicus                    8            0             0
## Geranium sp.                          0            7             0
## Hydrangea sp.                         0            0             6
## Ilex aquifolium                       0            0             0
## Ilex perado ssp. azorica              0            0             0
## Magnolia grandiflora                  0            0             0
## Magnolia soulangeana                  0            0             0
## Nerium oleander                       0            0             0
## Podocarpus sp.                        0            0             0
## Populus alba                          0            0             0
## Populus nigra                         0            0             0
## Primula vulgaris                      0            0             0
## Pseudosasa japonica                   0            0             0
## Quercus robur                         0            0             0
## Quercus suber                         0            0             0
## Salix atrocinera                      0            0             0
## Tilia tomentosa                       0            0             0
## Urtica dioica                         0            0             0
##                      Ilex aquifolium Ilex perado ssp. azorica
## Acca sellowiana                    0                        0
## Acer palmatum                      0                        0
```

```
## Alnus sp.                               0                     0
## Arisarum vulgare                        0                     0
## Betula pubescens                        1                     0
## Bougainvillea sp.                       0                     0
## Buxus sempervirens                      0                     0
## Castanea sativa                         0                     0
## Celtis sp.                              0                     0
## Corylus avellana                        0                     1
## Crataegus monogyna                      0                     0
## Erodium sp.                             0                     0
## Euonymus japonicus                      0                     0
## Geranium sp.                            0                     0
## Hydrangea sp.                           0                     0
## Ilex aquifolium                         4                     0
## Ilex perado ssp. azorica                0                     6
## Magnolia grandiflora                    0                     0
## Magnolia soulangeana                    0                     0
## Nerium oleander                         0                     0
## Podocarpus sp.                          0                     0
## Populus alba                            0                     0
## Populus nigra                           0                     0
## Primula vulgaris                        0                     0
## Pseudosasa japonica                     0                     0
## Quercus robur                           0                     0
## Quercus suber                           0                     0
## Salix atrocinera                        0                     1
## Tilia tomentosa                         0                     0
## Urtica dioica                           0                     0
##                         Magnolia grandiflora Magnolia soulangeana
## Acca sellowiana                            0                    0
## Acer palmatum                              0                    0
## Alnus sp.                                  0                    0
## Arisarum vulgare                           0                    0
## Betula pubescens                           0                    0
## Bougainvillea sp.                          0                    0
## Buxus sempervirens                         0                    0
## Castanea sativa                            0                    1
## Celtis sp.                                 0                    1
## Corylus avellana                           0                    0
## Crataegus monogyna                         0                    0
## Erodium sp.                                0                    0
## Euonymus japonicus                         0                    0
## Geranium sp.                               0                    0
## Hydrangea sp.                              1                    0
## Ilex aquifolium                            0                    0
## Ilex perado ssp. azorica                   0                    0
## Magnolia grandiflora                       3                    3
## Magnolia soulangeana                       3                    7
## Nerium oleander                            0                    0
## Podocarpus sp.                             0                    0
## Populus alba                               0                    0
## Populus nigra                              0                    0
## Primula vulgaris                           0                    1
## Pseudosasa japonica                        0                    0
```

```
## Quercus robur                                      0                     0
## Quercus suber                                      0                     0
## Salix atrocinera                                   0                     0
## Tilia tomentosa                                    0                     0
## Urtica dioica                                      0                     0
##                             Nerium oleander Podocarpus sp. Populus alba
## Acca sellowiana                           0              0            0
## Acer palmatum                             0              0            0
## Alnus sp.                                 0              0            0
## Arisarum vulgare                          0              0            0
## Betula pubescens                          0              0            0
## Bougainvillea sp.                         0              0            0
## Buxus sempervirens                        0              0            0
## Castanea sativa                           0              0            0
## Celtis sp.                                0              0            0
## Corylus avellana                          0              0            0
## Crataegus monogyna                        0              0            0
## Erodium sp.                               0              0            0
## Euonymus japonicus                        0              0            0
## Geranium sp.                              0              0            0
## Hydrangea sp.                             0              0            0
## Ilex aquifolium                           0              0            0
## Ilex perado ssp. azorica                  0              0            0
## Magnolia grandiflora                      0              0            0
## Magnolia soulangeana                      0              0            0
## Nerium oleander                          10              0            0
## Podocarpus sp.                            0              9            0
## Populus alba                              0              0            9
## Populus nigra                             0              0            0
## Primula vulgaris                          0              0            0
## Pseudosasa japonica                       0              1            0
## Quercus robur                             0              0            0
## Quercus suber                             0              0            0
## Salix atrocinera                          0              0            0
## Tilia tomentosa                           0              0            0
## Urtica dioica                             0              0            0
##                             Populus nigra Primula vulgaris Pseudosasa japonica
## Acca sellowiana                         0                0                   0
## Acer palmatum                           0                0                   0
## Alnus sp.                               0                0                   0
## Arisarum vulgare                        0                0                   0
## Betula pubescens                        0                0                   0
## Bougainvillea sp.                       0                0                   0
## Buxus sempervirens                      0                0                   0
## Castanea sativa                         0                1                   0
## Celtis sp.                              0                1                   0
## Corylus avellana                        0                0                   0
## Crataegus monogyna                      0                0                   0
## Erodium sp.                             0                0                   0
## Euonymus japonicus                      0                1                   0
## Geranium sp.                            0                0                   0
## Hydrangea sp.                           0                0                   0
## Ilex aquifolium                         0                0                   0
## Ilex perado ssp. azorica                0                0                   0
```

```
## Magnolia grandiflora            0              0              0
## Magnolia soulangeana            0              0              0
## Nerium oleander                 0              0              0
## Podocarpus sp.                  0              0              1
## Populus alba                    0              0              0
## Populus nigra                   2              0              0
## Primula vulgaris                0              3              0
## Pseudosasa japonica             0              0              7
## Quercus robur                   0              0              0
## Quercus suber                   0              0              0
## Salix atrocinera                0              0              0
## Tilia tomentosa                 0              0              0
## Urtica dioica                   0              0              0
##                         Quercus robur Quercus suber Salix atrocinera
## Acca sellowiana                     0             0                3
## Acer palmatum                       0             0                0
## Alnus sp.                           0             0                0
## Arisarum vulgare                    0             0                0
## Betula pubescens                    0             0                0
## Bougainvillea sp.                   0             1                0
## Buxus sempervirens                  0             0                0
## Castanea sativa                     0             0                0
## Celtis sp.                          0             0                0
## Corylus avellana                    0             0                0
## Crataegus monogyna                  0             0                0
## Erodium sp.                         0             0                0
## Euonymus japonicus                  0             0                0
## Geranium sp.                        0             0                0
## Hydrangea sp.                       0             1                0
## Ilex aquifolium                     1             0                0
## Ilex perado ssp. azorica            0             0                0
## Magnolia grandiflora                0             0                0
## Magnolia soulangeana                0             0                0
## Nerium oleander                     0             0                0
## Podocarpus sp.                      0             0                0
## Populus alba                        0             0                0
## Populus nigra                       0             0                0
## Primula vulgaris                    1             0                0
## Pseudosasa japonica                 0             0                0
## Quercus robur                       8             0                0
## Quercus suber                       0             5                0
## Salix atrocinera                    0             0                1
## Tilia tomentosa                     0             0                0
## Urtica dioica                       0             0                0
##                         Tilia tomentosa Urtica dioica class.error
## Acca sellowiana                       0             0   0.3750000
## Acer palmatum                         0             0   0.0000000
## Alnus sp.                             0             0   0.5000000
## Arisarum vulgare                      1             0   0.1250000
## Betula pubescens                      1             0   0.2727273
## Bougainvillea sp.                     0             0   0.1250000
## Buxus sempervirens                    0             0   0.1000000
## Castanea sativa                       0             0   0.3750000
## Celtis sp.                            0             0   0.4000000
```

```
## Corylus avellana                        0         0    0.4285714
## Crataegus monogyna                       0         0    0.1666667
## Erodium sp.                              0         1    0.1666667
## Euonymus japonicus                       0         0    0.1111111
## Geranium sp.                             0         0    0.1250000
## Hydrangea sp.                            0         0    0.3333333
## Ilex aquifolium                          0         0    0.3333333
## Ilex perado ssp. azorica                 0         0    0.2500000
## Magnolia grandiflora                     0         0    0.5000000
## Magnolia soulangeana                     0         0    0.3636364
## Nerium oleander                          0         0    0.0000000
## Podocarpus sp.                           0         0    0.1000000
## Populus alba                             0         0    0.0000000
## Populus nigra                            0         0    0.5000000
## Primula vulgaris                         0         0    0.5714286
## Pseudosasa japonica                      0         0    0.1250000
## Quercus robur                            0         0    0.0000000
## Quercus suber                            0         0    0.1666667
## Salix atrocinera                         0         0    0.8333333
## Tilia tomentosa                          5         0    0.2857143
## Urtica dioica                            0         5    0.1666667
```

```
prediction2 <- predict(model, test)
confusionMatrix(prediction2,test$Species)
```

```
## Confusion Matrix and Statistics
##
##                          Reference
## Prediction                Acca sellowiana Acer palmatum Alnus sp.
##     Acca sellowiana                     2             0         0
##     Acer palmatum                       0             3         0
##     Alnus sp.                           0             0         0
##     Arisarum vulgare                    0             0         0
##     Betula pubescens                    0             0         1
##     Bougainvillea sp.                   0             0         1
##     Buxus sempervirens                  0             0         0
##     Castanea sativa                     0             0         0
##     Celtis sp.                          0             0         0
##     Corylus avellana                    0             0         0
##     Crataegus monogyna                  0             0         0
##     Erodium sp.                         0             0         0
##     Euonymus japonicus                  0             0         0
##     Geranium sp.                        0             0         0
##     Hydrangea sp.                       0             0         0
##     Ilex aquifolium                     0             0         0
##     Ilex perado ssp. azorica            1             0         0
##     Magnolia grandiflora                0             0         0
##     Magnolia soulangeana                0             0         0
##     Nerium oleander                     0             0         0
##     Podocarpus sp.                      0             0         0
##     Populus alba                        0             0         0
##     Populus nigra                       0             0         0
##     Primula vulgaris                    0             0         0
##     Pseudosasa japonica                 0             0         0
##     Quercus robur                       0             0         0
```

```
##    Quercus suber                    0            0           0
##    Salix atrocinera                 0            0           0
##    Tilia tomentosa                  0            0           0
##    Urtica dioica                    0            0           0
##                        Reference
## Prediction             Arisarum vulgare Betula pubescens Bougainvillea sp.
##    Acca sellowiana                    0                0                 0
##    Acer palmatum                      0                0                 0
##    Alnus sp.                          0                0                 0
##    Arisarum vulgare                   1                0                 0
##    Betula pubescens                   0                2                 1
##    Bougainvillea sp.                  0                0                 4
##    Buxus sempervirens                 0                0                 0
##    Castanea sativa                    0                0                 0
##    Celtis sp.                         0                0                 0
##    Corylus avellana                   0                0                 0
##    Crataegus monogyna                 0                0                 0
##    Erodium sp.                        0                0                 0
##    Euonymus japonicus                 0                0                 0
##    Geranium sp.                       0                0                 0
##    Hydrangea sp.                      0                0                 0
##    Ilex aquifolium                    0                0                 0
##    Ilex perado ssp. azorica           0                0                 0
##    Magnolia grandiflora               0                0                 0
##    Magnolia soulangeana               0                0                 0
##    Nerium oleander                    0                0                 0
##    Podocarpus sp.                     0                0                 0
##    Populus alba                       0                0                 0
##    Populus nigra                      0                0                 0
##    Primula vulgaris                   0                0                 0
##    Pseudosasa japonica                0                0                 0
##    Quercus robur                      0                0                 0
##    Quercus suber                      0                0                 0
##    Salix atrocinera                   0                0                 0
##    Tilia tomentosa                    0                1                 0
##    Urtica dioica                      0                0                 0
##                       Reference
## Prediction             Buxus sempervirens Castanea sativa Celtis sp.
##    Acca sellowiana                      0               0          0
##    Acer palmatum                        0               0          0
##    Alnus sp.                            0               0          0
##    Arisarum vulgare                     0               0          0
##    Betula pubescens                     0               0          0
##    Bougainvillea sp.                    0               0          0
##    Buxus sempervirens                   2               0          0
##    Castanea sativa                      0               3          0
##    Celtis sp.                           0               0          6
##    Corylus avellana                     0               0          0
##    Crataegus monogyna                   0               0          0
##    Erodium sp.                          0               0          0
##    Euonymus japonicus                   0               0          0
##    Geranium sp.                         0               0          0
##    Hydrangea sp.                        0               0          0
##    Ilex aquifolium                      0               0          0
```

```
##    Ilex perado ssp. azorica            0            0         0
##    Magnolia grandiflora                0            0         0
##    Magnolia soulangeana                0            1         0
##    Nerium oleander                     0            0         0
##    Podocarpus sp.                      0            0         0
##    Populus alba                        0            0         0
##    Populus nigra                       0            0         0
##    Primula vulgaris                    0            0         1
##    Pseudosasa japonica                 0            0         0
##    Quercus robur                       0            0         0
##    Quercus suber                       0            0         0
##    Salix atrocinera                    0            0         0
##    Tilia tomentosa                     0            0         0
##    Urtica dioica                       0            0         0
##                          Reference
## Prediction               Corylus avellana Crataegus monogyna Erodium sp.
##    Acca sellowiana                      0                  0           0
##    Acer palmatum                        0                  0           0
##    Alnus sp.                            0                  0           0
##    Arisarum vulgare                     0                  0           0
##    Betula pubescens                     0                  0           0
##    Bougainvillea sp.                    0                  0           0
##    Buxus sempervirens                   0                  0           0
##    Castanea sativa                      0                  0           0
##    Celtis sp.                           0                  0           0
##    Corylus avellana                     3                  0           0
##    Crataegus monogyna                   0                  1           0
##    Erodium sp.                          0                  0           5
##    Euonymus japonicus                   0                  0           0
##    Geranium sp.                         0                  0           0
##    Hydrangea sp.                        2                  0           0
##    Ilex aquifolium                      0                  0           0
##    Ilex perado ssp. azorica             1                  0           0
##    Magnolia grandiflora                 0                  0           0
##    Magnolia soulangeana                 0                  0           0
##    Nerium oleander                      0                  0           0
##    Podocarpus sp.                       0                  0           0
##    Populus alba                         0                  1           0
##    Populus nigra                        0                  0           0
##    Primula vulgaris                     0                  0           0
##    Pseudosasa japonica                  0                  0           0
##    Quercus robur                        0                  0           0
##    Quercus suber                        0                  0           0
##    Salix atrocinera                     0                  0           0
##    Tilia tomentosa                      0                  0           0
##    Urtica dioica                        0                  0           0
##                          Reference
## Prediction               Euonymus japonicus Geranium sp. Hydrangea sp.
##    Acca sellowiana                       0            0             0
##    Acer palmatum                         0            0             0
##    Alnus sp.                             0            0             0
##    Arisarum vulgare                      0            0             0
##    Betula pubescens                      0            0             0
##    Bougainvillea sp.                     1            0             1
```

```
##    Buxus sempervirens                      0            0            0
##    Castanea sativa                         0            0            0
##    Celtis sp.                              0            0            0
##    Corylus avellana                        2            0            1
##    Crataegus monogyna                      0            1            0
##    Erodium sp.                             0            0            0
##    Euonymus japonicus                      0            0            0
##    Geranium sp.                            0            1            0
##    Hydrangea sp.                           0            0            0
##    Ilex aquifolium                         0            0            0
##    Ilex perado ssp. azorica                0            0            0
##    Magnolia grandiflora                    0            0            0
##    Magnolia soulangeana                    0            0            0
##    Nerium oleander                         0            0            0
##    Podocarpus sp.                          0            0            0
##    Populus alba                            0            0            0
##    Populus nigra                           0            0            0
##    Primula vulgaris                        0            0            0
##    Pseudosasa japonica                     0            0            0
##    Quercus robur                           0            0            0
##    Quercus suber                           0            0            0
##    Salix atrocinera                        0            0            0
##    Tilia tomentosa                         0            0            0
##    Urtica dioica                           0            0            0
##                             Reference
## Prediction                 Ilex aquifolium Ilex perado ssp. azorica
##    Acca sellowiana                1                            1
##    Acer palmatum                  0                            0
##    Alnus sp.                      0                            0
##    Arisarum vulgare               0                            0
##    Betula pubescens               0                            0
##    Bougainvillea sp.              0                            1
##    Buxus sempervirens             0                            0
##    Castanea sativa                0                            0
##    Celtis sp.                     0                            0
##    Corylus avellana               0                            1
##    Crataegus monogyna             0                            0
##    Erodium sp.                    0                            0
##    Euonymus japonicus             0                            0
##    Geranium sp.                   0                            0
##    Hydrangea sp.                  0                            0
##    Ilex aquifolium                2                            0
##    Ilex perado ssp. azorica       0                            0
##    Magnolia grandiflora           0                            0
##    Magnolia soulangeana           0                            0
##    Nerium oleander                0                            0
##    Podocarpus sp.                 0                            0
##    Populus alba                   1                            0
##    Populus nigra                  0                            0
##    Primula vulgaris               0                            0
##    Pseudosasa japonica            0                            0
##    Quercus robur                  0                            0
##    Quercus suber                  0                            0
##    Salix atrocinera               0                            0
```

```
##    Tilia tomentosa                               0                        0
##    Urtica dioica                                 0                        0
##                              Reference
## Prediction             Magnolia grandiflora Magnolia soulangeana
##    Acca sellowiana                        0                     0
##    Acer palmatum                          0                     0
##    Alnus sp.                              0                     0
##    Arisarum vulgare                       0                     0
##    Betula pubescens                       0                     0
##    Bougainvillea sp.                      0                     0
##    Buxus sempervirens                     0                     0
##    Castanea sativa                        0                     0
##    Celtis sp.                             0                     0
##    Corylus avellana                       0                     0
##    Crataegus monogyna                     0                     0
##    Erodium sp.                            0                     0
##    Euonymus japonicus                     0                     0
##    Geranium sp.                           0                     0
##    Hydrangea sp.                          0                     0
##    Ilex aquifolium                        0                     0
##    Ilex perado ssp. azorica               0                     0
##    Magnolia grandiflora                   3                     0
##    Magnolia soulangeana                   1                     1
##    Nerium oleander                        0                     0
##    Podocarpus sp.                         0                     0
##    Populus alba                           0                     0
##    Populus nigra                          0                     0
##    Primula vulgaris                       1                     0
##    Pseudosasa japonica                    0                     0
##    Quercus robur                          0                     0
##    Quercus suber                          0                     0
##    Salix atrocinera                       0                     0
##    Tilia tomentosa                        0                     0
##    Urtica dioica                          0                     0
##                              Reference
## Prediction             Nerium oleander Podocarpus sp. Populus alba
##    Acca sellowiana                   0              0            0
##    Acer palmatum                     0              0            0
##    Alnus sp.                         0              0            0
##    Arisarum vulgare                  0              0            0
##    Betula pubescens                  0              0            0
##    Bougainvillea sp.                 0              0            0
##    Buxus sempervirens                0              0            0
##    Castanea sativa                   0              0            0
##    Celtis sp.                        0              0            0
##    Corylus avellana                  0              0            0
##    Crataegus monogyna                0              0            0
##    Erodium sp.                       0              0            0
##    Euonymus japonicus                0              0            0
##    Geranium sp.                      0              0            0
##    Hydrangea sp.                     0              0            0
##    Ilex aquifolium                   0              0            0
##    Ilex perado ssp. azorica          0              0            0
##    Magnolia grandiflora              0              0            0
```

```
##    Magnolia soulangeana                   0              0              0
##    Nerium oleander                        1              0              0
##    Podocarpus sp.                         0              1              0
##    Populus alba                           0              0              1
##    Populus nigra                          0              0              0
##    Primula vulgaris                       0              0              0
##    Pseudosasa japonica                    0              0              0
##    Quercus robur                          0              0              0
##    Quercus suber                          0              0              0
##    Salix atrocinera                       0              0              0
##    Tilia tomentosa                        0              0              0
##    Urtica dioica                          0              0              0
##                              Reference
## Prediction                   Populus nigra Primula vulgaris Pseudosasa japonica
##    Acca sellowiana                       0                0                   0
##    Acer palmatum                         0                0                   0
##    Alnus sp.                             0                0                   0
##    Arisarum vulgare                      1                0                   0
##    Betula pubescens                      0                0                   0
##    Bougainvillea sp.                     0                0                   0
##    Buxus sempervirens                    0                0                   0
##    Castanea sativa                       0                0                   0
##    Celtis sp.                            0                0                   0
##    Corylus avellana                      0                0                   0
##    Crataegus monogyna                    0                0                   0
##    Erodium sp.                           1                0                   0
##    Euonymus japonicus                    0                0                   0
##    Geranium sp.                          0                0                   0
##    Hydrangea sp.                         0                0                   0
##    Ilex aquifolium                       0                0                   0
##    Ilex perado ssp. azorica              0                0                   0
##    Magnolia grandiflora                  0                0                   0
##    Magnolia soulangeana                  0                0                   0
##    Nerium oleander                       0                1                   0
##    Podocarpus sp.                        0                0                   2
##    Populus alba                          0                0                   0
##    Populus nigra                         4                0                   0
##    Primula vulgaris                      0                4                   0
##    Pseudosasa japonica                   0                0                   1
##    Quercus robur                         0                0                   0
##    Quercus suber                         0                0                   0
##    Salix atrocinera                      0                0                   0
##    Tilia tomentosa                       0                0                   0
##    Urtica dioica                         0                0                   0
##                              Reference
## Prediction                   Quercus robur Quercus suber Salix atrocinera
##    Acca sellowiana                       0             0                1
##    Acer palmatum                         0             0                0
##    Alnus sp.                             0             0                0
##    Arisarum vulgare                      0             0                0
##    Betula pubescens                      0             0                0
##    Bougainvillea sp.                     0             0                0
##    Buxus sempervirens                    0             0                0
##    Castanea sativa                       0             0                0
```

```
##    Celtis sp.                        0          0          0
##    Corylus avellana                  0          1          0
##    Crataegus monogyna                0          0          0
##    Erodium sp.                       0          0          0
##    Euonymus japonicus                0          1          0
##    Geranium sp.                      0          0          0
##    Hydrangea sp.                     0          0          0
##    Ilex aquifolium                   0          0          0
##    Ilex perado ssp. azorica          0          0          0
##    Magnolia grandiflora              0          0          0
##    Magnolia soulangeana              0          0          0
##    Nerium oleander                   0          0          0
##    Podocarpus sp.                    0          0          0
##    Populus alba                      0          0          0
##    Populus nigra                     0          0          0
##    Primula vulgaris                  0          0          0
##    Pseudosasa japonica               0          0          0
##    Quercus robur                     4          0          0
##    Quercus suber                     0          4          0
##    Salix atrocinera                  0          0          3
##    Tilia tomentosa                   0          0          0
##    Urtica dioica                     0          0          0
##                          Reference
## Prediction               Tilia tomentosa Urtica dioica
##    Acca sellowiana                   0          0
##    Acer palmatum                     0          0
##    Alnus sp.                         0          0
##    Arisarum vulgare                  0          0
##    Betula pubescens                  0          0
##    Bougainvillea sp.                 0          0
##    Buxus sempervirens                0          0
##    Castanea sativa                   0          0
##    Celtis sp.                        0          0
##    Corylus avellana                  0          0
##    Crataegus monogyna                0          0
##    Erodium sp.                       0          0
##    Euonymus japonicus                0          0
##    Geranium sp.                      0          0
##    Hydrangea sp.                     0          0
##    Ilex aquifolium                   0          0
##    Ilex perado ssp. azorica          0          0
##    Magnolia grandiflora              0          0
##    Magnolia soulangeana              0          0
##    Nerium oleander                   0          0
##    Podocarpus sp.                    0          0
##    Populus alba                      0          0
##    Populus nigra                     0          0
##    Primula vulgaris                  0          0
##    Pseudosasa japonica               0          0
##    Quercus robur                     0          0
##    Quercus suber                     0          0
##    Salix atrocinera                  0          0
##    Tilia tomentosa                   6          0
##    Urtica dioica                     0          6
```

```
##
## Overall Statistics
##
##                   Accuracy : 0.6981
##                     95% CI : (0.6013, 0.7835)
##        No Information Rate : 0.066
##        P-Value [Acc > NIR] : < 2.2e-16
##
##                      Kappa : 0.6854
##
##   Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                        Class: Acca sellowiana Class: Acer palmatum
## Sensitivity                          0.66667               1.0000
## Specificity                          0.97087               1.0000
## Pos Pred Value                       0.40000               1.0000
## Neg Pred Value                       0.99010               1.0000
## Prevalence                           0.02830               0.0283
## Detection Rate                       0.01887               0.0283
## Detection Prevalence                 0.04717               0.0283
## Balanced Accuracy                    0.81877               1.0000
##                        Class: Alnus sp. Class: Arisarum vulgare
## Sensitivity                    0.00000                1.000000
## Specificity                    1.00000                0.990476
## Pos Pred Value                     NaN                0.500000
## Neg Pred Value                 0.98113                1.000000
## Prevalence                     0.01887                0.009434
## Detection Rate                 0.00000                0.009434
## Detection Prevalence           0.00000                0.018868
## Balanced Accuracy              0.50000                0.995238
##                        Class: Betula pubescens Class: Bougainvillea sp.
## Sensitivity                           0.66667                  0.80000
## Specificity                           0.98058                  0.96040
## Pos Pred Value                        0.50000                  0.50000
## Neg Pred Value                        0.99020                  0.98980
## Prevalence                            0.02830                  0.04717
## Detection Rate                        0.01887                  0.03774
## Detection Prevalence                  0.03774                  0.07547
## Balanced Accuracy                     0.82362                  0.88020
##                        Class: Buxus sempervirens Class: Castanea sativa
## Sensitivity                             1.00000                0.75000
## Specificity                             1.00000                1.00000
## Pos Pred Value                          1.00000                1.00000
## Neg Pred Value                          1.00000                0.99029
## Prevalence                              0.01887                0.03774
## Detection Rate                          0.01887                0.02830
## Detection Prevalence                    0.01887                0.02830
## Balanced Accuracy                       1.00000                0.87500
##                        Class: Celtis sp. Class: Corylus avellana
## Sensitivity                     0.85714                 0.50000
## Specificity                     1.00000                 0.95000
## Pos Pred Value                  1.00000                 0.37500
```

```
## Neg Pred Value                       0.99000                   0.96939
## Prevalence                           0.06604                   0.05660
## Detection Rate                       0.05660                   0.02830
## Detection Prevalence                 0.05660                   0.07547
## Balanced Accuracy                    0.92857                   0.72500
##                      Class: Crataegus monogyna Class: Erodium sp.
## Sensitivity                         0.500000                  1.00000
## Specificity                         0.990385                  0.99010
## Pos Pred Value                      0.500000                  0.83333
## Neg Pred Value                      0.990385                  1.00000
## Prevalence                          0.018868                  0.04717
## Detection Rate                      0.009434                  0.04717
## Detection Prevalence                0.018868                  0.05660
## Balanced Accuracy                   0.745192                  0.99505
##                      Class: Euonymus japonicus Class: Geranium sp.
## Sensitivity                         0.000000                  0.500000
## Specificity                         0.990291                  1.000000
## Pos Pred Value                      0.000000                  1.000000
## Neg Pred Value                      0.971429                  0.990476
## Prevalence                          0.028302                  0.018868
## Detection Rate                      0.000000                  0.009434
## Detection Prevalence                0.009434                  0.009434
## Balanced Accuracy                   0.495146                  0.750000
##                      Class: Hydrangea sp. Class: Ilex aquifolium
## Sensitivity                       0.00000                  0.50000
## Specificity                       0.98077                  1.00000
## Pos Pred Value                    0.00000                  1.00000
## Neg Pred Value                    0.98077                  0.98077
## Prevalence                        0.01887                  0.03774
## Detection Rate                    0.00000                  0.01887
## Detection Prevalence              0.01887                  0.01887
## Balanced Accuracy                 0.49038                  0.75000
##                      Class: Ilex perado ssp. azorica
## Sensitivity                              0.00000
## Specificity                              0.98058
## Pos Pred Value                           0.00000
## Neg Pred Value                           0.97115
## Prevalence                               0.02830
## Detection Rate                           0.00000
## Detection Prevalence                     0.01887
## Balanced Accuracy                        0.49029
##                      Class: Magnolia grandiflora Class: Magnolia soulangeana
## Sensitivity                           0.60000                    1.000000
## Specificity                           1.00000                    0.980952
## Pos Pred Value                        1.00000                    0.333333
## Neg Pred Value                        0.98058                    1.000000
## Prevalence                            0.04717                    0.009434
## Detection Rate                        0.02830                    0.009434
## Detection Prevalence                  0.02830                    0.028302
## Balanced Accuracy                     0.80000                    0.990476
##                      Class: Nerium oleander Class: Podocarpus sp.
## Sensitivity                         1.000000                  1.000000
## Specificity                         0.990476                  0.980952
## Pos Pred Value                      0.500000                  0.333333
```

```
## Neg Pred Value                     1.000000              1.000000
## Prevalence                         0.009434              0.009434
## Detection Rate                     0.009434              0.009434
## Detection Prevalence               0.018868              0.028302
## Balanced Accuracy                  0.995238              0.990476
##                      Class: Populus alba Class: Populus nigra
## Sensitivity                       1.000000               0.66667
## Specificity                       0.980952               1.00000
## Pos Pred Value                    0.333333               1.00000
## Neg Pred Value                    1.000000               0.98039
## Prevalence                        0.009434               0.05660
## Detection Rate                    0.009434               0.03774
## Detection Prevalence              0.028302               0.03774
## Balanced Accuracy                 0.990476               0.83333
##                      Class: Primula vulgaris Class: Pseudosasa japonica
## Sensitivity                         0.80000                   0.333333
## Specificity                         0.98020                   1.000000
## Pos Pred Value                      0.66667                   1.000000
## Neg Pred Value                      0.99000                   0.980952
## Prevalence                          0.04717                   0.028302
## Detection Rate                      0.03774                   0.009434
## Detection Prevalence                0.05660                   0.009434
## Balanced Accuracy                   0.89010                   0.666667
##                      Class: Quercus robur Class: Quercus suber
## Sensitivity                       1.00000              0.66667
## Specificity                       1.00000              1.00000
## Pos Pred Value                    1.00000              1.00000
## Neg Pred Value                    1.00000              0.98039
## Prevalence                        0.03774              0.05660
## Detection Rate                    0.03774              0.03774
## Detection Prevalence              0.03774              0.03774
## Balanced Accuracy                 1.00000              0.83333
##                      Class: Salix atrocinera Class: Tilia tomentosa
## Sensitivity                         0.75000                1.00000
## Specificity                         1.00000                0.99000
## Pos Pred Value                      1.00000                0.85714
## Neg Pred Value                      0.99029                1.00000
## Prevalence                          0.03774                0.05660
## Detection Rate                      0.02830                0.05660
## Detection Prevalence                0.02830                0.06604
## Balanced Accuracy                   0.87500                0.99500
##                      Class: Urtica dioica
## Sensitivity                        1.0000
## Specificity                        1.0000
## Pos Pred Value                     1.0000
## Neg Pred Value                     1.0000
## Prevalence                         0.0566
## Detection Rate                     0.0566
## Detection Prevalence               0.0566
## Balanced Accuracy                  1.0000

#histogram of numbers of nodes
hist(treesize(model), main="no of nodes",col="green")
```

no of nodes


```
#Variance importance
varImpPlot(model)
```
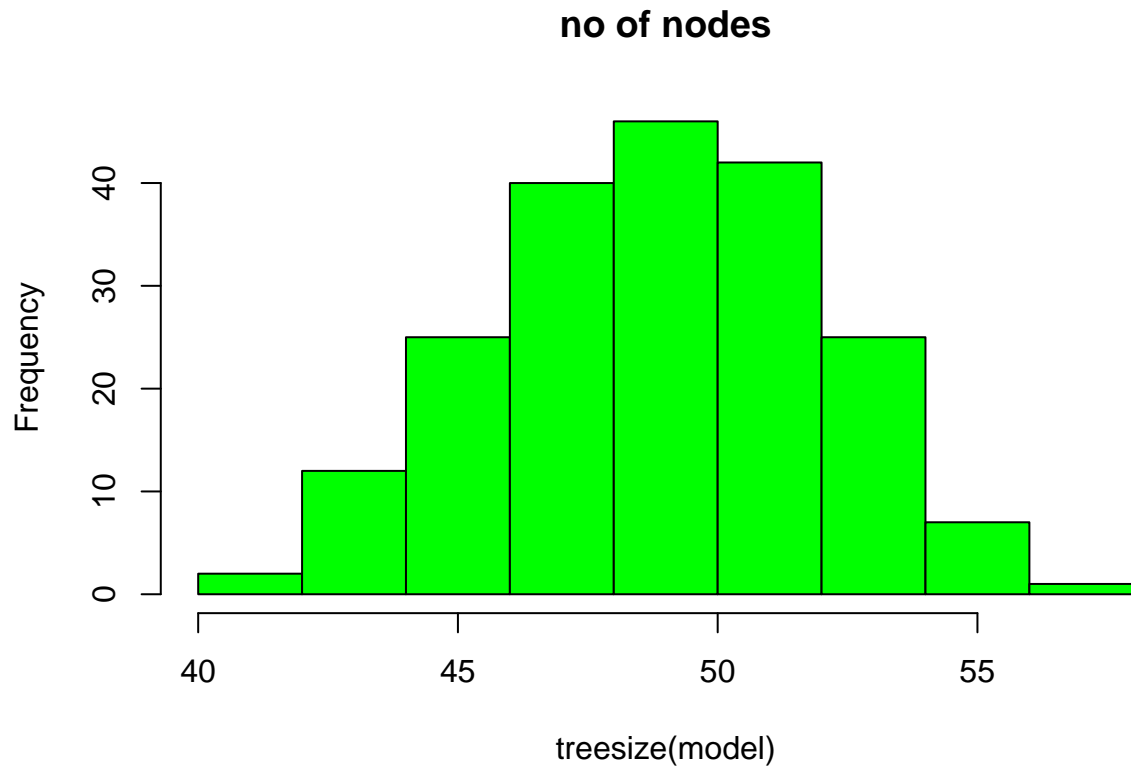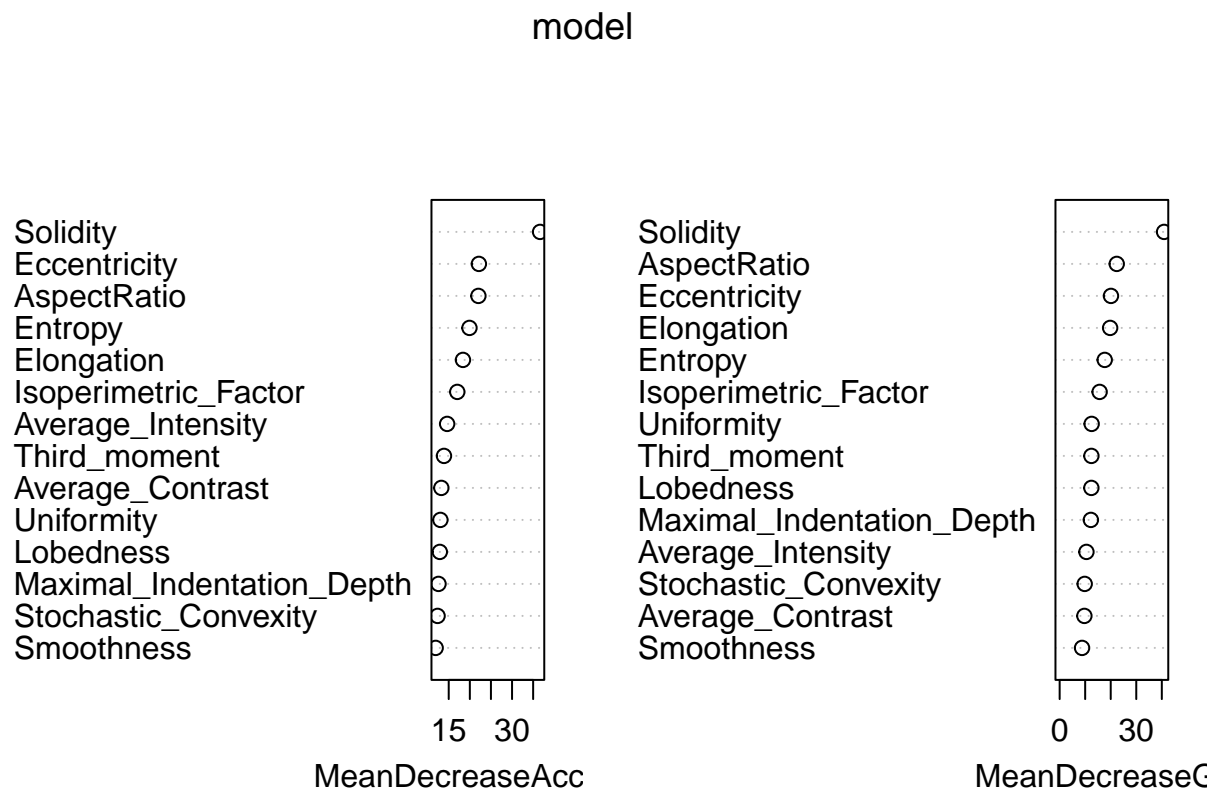
model


```
#Variance importance
varImpPlot(model, sort = T, n.var=10, main = "top10-variableimportance")
```

top10−variableimportance

	MeanDecreaseAccuracy		MeanDecreaseGini
Solidity	○ (high)	Solidity	○ (high)
Eccentricity	○	AspectRatio	○
AspectRatio	○	Eccentricity	○
Entropy	○	Elongation	○
Elongation	○	Entropy	○
Isoperimetric_Factor	○	Isoperimetric_Factor	○
Average_Intensity	○	Uniformity	○
Third_moment	○	Third_moment	○
Average_Contrast	○	Lobedness	○
Uniformity	○	Maximal_Indentation_Depth	○
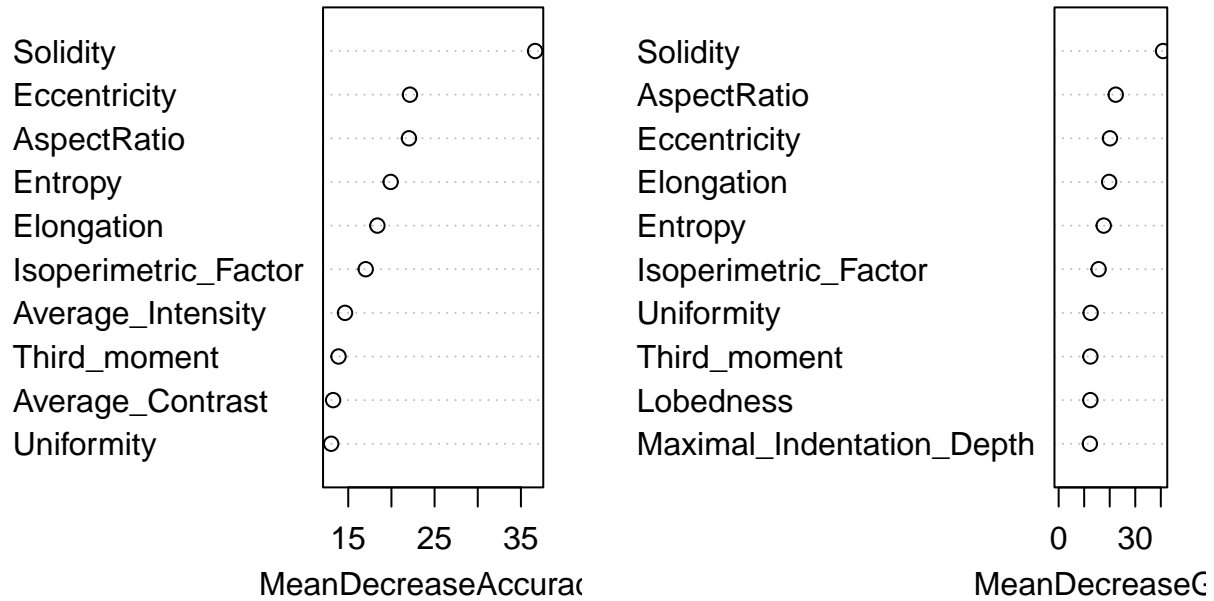
```r
#Variance importance
importance(model)
```

```
##                            Acca sellowiana Acer palmatum Alnus sp.
## Eccentricity                     4.6984116      3.306644 4.5722541
## AspectRatio                      4.4172055      4.255595 3.4061887
## Elongation                       3.5372143      5.132784 2.0099731
## Solidity                         7.4666079     27.793674 4.5331367
## Stochastic_Convexity             1.1066098      5.470312 0.7454111
## Isoperimetric_Factor             2.1581741      6.502022 3.7630912
## Maximal_Indentation_Depth        2.5896179      3.449306 4.1112504
## Lobedness                        2.0522778      3.707822 4.2044233
## Average_Intensity                3.5540503      3.978098 1.6653505
## Average_Contrast                -0.8518302      3.890018 1.5790211
## Smoothness                       1.3352650      2.809544 1.7362192
## Third_moment                     1.5990812      2.228090 4.0377288
## Uniformity                       2.8807992      3.447021 0.9114983
## Entropy                          4.1928882      3.992627 1.0000000
##                            Arisarum vulgare Betula pubescens Bougainvillea sp.
## Eccentricity                       7.543899         9.265561        5.71917122
## AspectRatio                        7.926094         9.159190        5.13925213
## Elongation                         4.649133         5.720491        5.58308853
## Solidity                           8.173398        11.782053        8.22581304
## Stochastic_Convexity               1.848286         4.367140        2.17875184
## Isoperimetric_Factor               5.559779         6.052368        5.78647386
## Maximal_Indentation_Depth          4.620999         3.785628        5.32171497
## Lobedness                          3.689871         3.601425        1.02668692
## Average_Intensity                  5.190701         1.577348        1.29763781
## Average_Contrast                   6.474874         3.324288        2.60782330
```

```
## Smoothness                        5.724114       1.834769      1.76379427
## Third_moment                      5.315846       3.396333      5.68181336
## Uniformity                        4.595763       1.730772      0.01449428
## Entropy                           4.977255       3.053508      2.07478425
##                         Buxus sempervirens Castanea sativa Celtis sp.
## Eccentricity                      6.154968       5.6810944  4.3218362
## AspectRatio                       8.204577       5.2404643  3.1370194
## Elongation                        3.946762       2.6070698  1.4294800
## Solidity                          8.068473       7.0009822  6.2403250
## Stochastic_Convexity              5.364861       1.0425766  2.6713002
## Isoperimetric_Factor              4.605921       2.8932439  0.4800845
## Maximal_Indentation_Depth         5.920996       5.1955555  1.9242809
## Lobedness                         4.192612       5.6263741  1.6358643
## Average_Intensity                 8.033660       0.8428100  2.1985076
## Average_Contrast                  6.473644       1.3091332  2.0941562
## Smoothness                        5.807368       2.4584298  0.7789567
## Third_moment                      5.347296      -0.2719305  2.1574849
## Uniformity                        5.012581       1.8399420  2.1355053
## Entropy                           6.038984       3.7154055  6.5970649
##                         Corylus avellana Crataegus monogyna Erodium sp.
## Eccentricity                  6.39901996           3.986238    5.009179
## AspectRatio                   5.46571616           4.506850    5.214095
## Elongation                    5.02980119           4.526542    3.225201
## Solidity                     13.68265514           7.059508    7.404783
## Stochastic_Convexity          3.74562653           6.933019    3.886122
## Isoperimetric_Factor          7.34389351           2.935158    4.489663
## Maximal_Indentation_Depth     4.57546894           6.008207    2.579737
## Lobedness                     4.96597363           5.760746    3.189864
## Average_Intensity             2.27958890           1.901262    2.873089
## Average_Contrast              0.50572623           3.459983    2.496498
## Smoothness                   -0.04603439           2.504468    2.705412
## Third_moment                  2.21662130           2.802177    1.295890
## Uniformity                   -1.01460989           2.522136    3.258116
## Entropy                      -0.40150175           2.387994    5.444093
##                         Euonymus japonicus Geranium sp. Hydrangea sp.
## Eccentricity                    4.9184335     5.185286      6.517459
## AspectRatio                     5.6355368     4.840496      6.638763
## Elongation                      4.8705781    10.845143      4.538673
## Solidity                       10.4120755     6.333062      9.450500
## Stochastic_Convexity            3.9742723     8.346683      3.783140
## Isoperimetric_Factor            5.7533180     8.127115      3.425912
## Maximal_Indentation_Depth       1.7384177     3.470372      3.537411
## Lobedness                       3.3885005     3.738620      4.436870
## Average_Intensity               1.0164194     2.644590      4.350189
## Average_Contrast                0.7879443     5.057489      3.421328
## Smoothness                      1.4749135     4.902901      3.599531
## Third_moment                    3.2281897     3.059487      6.423660
## Uniformity                      4.2648162     2.577920      8.077739
## Entropy                         1.6528196     4.055484      3.334481
##                         Ilex aquifolium Ilex perado ssp. azorica
## Eccentricity                  6.0750726                7.6666440
## AspectRatio                   6.1371562                5.5171709
## Elongation                    3.6664837                4.1417629
## Solidity                      6.0794216               19.7679451
```

```
## Stochastic_Convexity                    3.1569746                    3.9788524
## Isoperimetric_Factor                     1.7635693                    5.8934355
## Maximal_Indentation_Depth                0.5385331                    3.1774797
## Lobedness                                2.3458060                    3.8233943
## Average_Intensity                        0.9427347                    2.8971799
## Average_Contrast                         1.9277090                    2.0213533
## Smoothness                               1.5022158                    3.7426336
## Third_moment                             1.7964040                    4.3392108
## Uniformity                               3.1444141                    1.3434636
## Entropy                                  2.6401990                    0.3501667
##                             Magnolia grandiflora Magnolia soulangeana
## Eccentricity                           5.4073950            8.2429492
## AspectRatio                            3.8073883            9.8495487
## Elongation                             3.1286877            5.2594049
## Solidity                               6.6334446            9.2452303
## Stochastic_Convexity                   2.2666599            3.9539392
## Isoperimetric_Factor                   3.5006009            3.9015889
## Maximal_Indentation_Depth              2.2327214            0.7685704
## Lobedness                              0.2531507           -0.3332996
## Average_Intensity                      2.8895977            3.2242168
## Average_Contrast                       1.7677670            3.8717488
## Smoothness                             2.8261671            3.3714507
## Third_moment                           3.2145649            2.5456871
## Uniformity                             7.9989260            1.8602979
## Entropy                                4.2294300            7.8584767
##                             Nerium oleander Podocarpus sp. Populus alba
## Eccentricity                      10.769681      8.6455973     7.309993
## AspectRatio                       10.527438      9.0155665     7.630521
## Elongation                         9.666275     10.6731152     7.475074
## Solidity                           8.249422      5.4119703    13.253811
## Stochastic_Convexity               1.980540      1.7699733     3.495888
## Isoperimetric_Factor               6.889213      5.7766688     7.158392
## Maximal_Indentation_Depth          2.090768      2.5289169     6.332538
## Lobedness                          2.501640      2.5313535     6.083660
## Average_Intensity                  3.239845      4.3396667     4.258950
## Average_Contrast                   2.390682      0.5003128     3.513227
## Smoothness                         1.565537      1.7953644     3.548598
## Third_moment                       2.164942     -0.1878839     3.132063
## Uniformity                         2.657424      3.4127135     2.426842
## Entropy                            3.892043     13.9587098     4.187781
##                             Populus nigra Primula vulgaris Pseudosasa japonica
## Eccentricity                     5.537491       5.46107875          9.86959357
## AspectRatio                      7.036993       6.40920809         11.69243725
## Elongation                       5.285267       3.12598847          8.44946403
## Solidity                         6.855539       2.16639801          6.27619058
## Stochastic_Convexity             0.745241      -0.04558891          2.22322662
## Isoperimetric_Factor             2.518726       3.54465453          6.07378199
## Maximal_Indentation_Depth        3.493456       2.22304864          3.49184355
## Lobedness                        2.406366       1.93100349          2.56880867
## Average_Intensity                2.693304       0.87778845          0.07996079
## Average_Contrast                 1.906925       0.19142027          0.59410938
## Smoothness                       1.745189       0.16732513          1.00250941
## Third_moment                     4.586111       0.19602811          1.39809402
## Uniformity                       3.397347      -0.44308383         -0.52266553
```

```
## Entropy                         2.348788        6.41999833         3.26219370
##                        Quercus robur Quercus suber Salix atrocinera
## Eccentricity               7.6675164      4.119867         3.8939182
## AspectRatio                5.3185942      3.335908         2.8631229
## Elongation                 6.6423881      3.234746        -0.8928667
## Solidity                  10.4957459      5.273280         1.6439767
## Stochastic_Convexity      10.6030558      3.617697         2.9583701
## Isoperimetric_Factor       7.2219588      5.922925         3.7124730
## Maximal_Indentation_Depth  5.7290103      6.789575         1.7430739
## Lobedness                  4.3425996      5.397172         2.0525271
## Average_Intensity          3.3705414      5.021261         0.1807163
## Average_Contrast           2.2755715      4.363714         0.7357973
## Smoothness                 0.7542122      4.038176         0.8124445
## Third_moment               1.7989867      4.568824         2.6538612
## Uniformity                 2.8205795      3.819800        -0.1737620
## Entropy                    3.9995233      3.131466         0.9108037
##                        Tilia tomentosa Urtica dioica MeanDecreaseAccuracy
## Eccentricity                  6.999871  7.179063e+00             22.14583
## AspectRatio                   5.589700  5.399321e+00             22.02938
## Elongation                    5.189820  7.129896e+00             18.37161
## Solidity                      7.441424  7.601248e+00             36.64479
## Stochastic_Convexity          3.897487  2.863896e+00             12.35835
## Isoperimetric_Factor          2.437613  6.157023e+00             17.02238
## Maximal_Indentation_Depth     5.388163  3.890883e+00             12.57608
## Lobedness                     6.796861  3.233699e+00             12.88976
## Average_Intensity             4.253031  2.210788e+00             14.62523
## Average_Contrast              3.866884 -2.177326e-16             13.24943
## Smoothness                    3.776501 -4.767335e-01             11.89932
## Third_moment                  3.104743  1.285772e+00             13.87276
## Uniformity                    1.459457  9.835257e-01             13.02422
## Entropy                       2.588587  3.141332e+00             19.91445
##                        MeanDecreaseGini
## Eccentricity                  20.095891
## AspectRatio                   22.351723
## Elongation                    19.769285
## Solidity                      40.891452
## Stochastic_Convexity           9.801790
## Isoperimetric_Factor          15.655298
## Maximal_Indentation_Depth     12.224284
## Lobedness                     12.416128
## Average_Intensity             10.488087
## Average_Contrast               9.677114
## Smoothness                     8.771683
## Third_moment                  12.429959
## Uniformity                    12.536582
## Entropy                       17.643930
#Variance actually used by the random forest
varUsed(model)
```

```
##  [1]  829  876  775 1372  420  695  603  620  512  476  452  633  635  762
```

```
#partial dependence plot
#partialPlot(model,train, solidity, "Quercus suber")
```

```
getTree(model,1, labelVar = TRUE)
```

```
##    left daughter right daughter                split var split point status
## 1               2              3               Elongation  0.909850000      1
## 2               4              5                 Solidity  0.615245000      1
## 3               6              7              AspectRatio 13.808000000      1
## 4               0              0                     <NA>  0.000000000     -1
## 5               8              9         Average_Contrast  0.063108500      1
## 6               0              0                     <NA>  0.000000000     -1
## 7               0              0                     <NA>  0.000000000     -1
## 8              10             11 Maximal_Indentation_Depth  0.007945300      1
## 9              12             13                 Solidity  0.749935000      1
## 10              0              0                     <NA>  0.000000000     -1
## 11             14             15              AspectRatio  1.445900000      1
## 12             16             17      Stochastic_Convexity  0.774560000      1
## 13             18             19              AspectRatio  2.087550000      1
## 14             20             21                 Solidity  0.902685000      1
## 15              0              0                     <NA>  0.000000000     -1
## 16              0              0                     <NA>  0.000000000     -1
## 17              0              0                     <NA>  0.000000000     -1
## 18             22             23                 Solidity  0.984640000      1
## 19             24             25               Uniformity  0.000318300      1
## 20              0              0                     <NA>  0.000000000     -1
## 21              0              0                     <NA>  0.000000000     -1
## 22             26             27                 Solidity  0.973600000      1
## 23             28             29                 Solidity  0.988435000      1
## 24             30             31               Elongation  0.768795000      1
## 25             32             33              AspectRatio  2.658300000      1
## 26             34             35                  Entropy  0.528210000      1
## 27             36             37               Uniformity  0.000465830      1
## 28             38             39                 Lobedness  0.014824500      1
## 29             40             41               Uniformity  0.000424565      1
## 30             42             43                  Entropy  1.157000000      1
## 31             44             45              AspectRatio  8.438550000      1
## 32             46             47             Third_moment  0.010657750      1
## 33              0              0                     <NA>  0.000000000     -1
## 34              0              0                     <NA>  0.000000000     -1
## 35             48             49               Smoothness  0.055212500      1
## 36             50             51              AspectRatio  1.917750000      1
## 37              0              0                     <NA>  0.000000000     -1
## 38              0              0                     <NA>  0.000000000     -1
## 39              0              0                     <NA>  0.000000000     -1
## 40              0              0                     <NA>  0.000000000     -1
## 41              0              0                     <NA>  0.000000000     -1
## 42             52             53                 Lobedness  0.071656500      1
## 43             54             55 Maximal_Indentation_Depth  0.041305000      1
## 44              0              0                     <NA>  0.000000000     -1
## 45             56             57               Uniformity  0.000056864      1
## 46              0              0                     <NA>  0.000000000     -1
## 47             58             59                 Solidity  0.977905000      1
## 48             60             61              AspectRatio  1.597500000      1
## 49              0              0                     <NA>  0.000000000     -1
## 50             62             63                 Solidity  0.981680000      1
## 51              0              0                     <NA>  0.000000000     -1
```

```
## 52                64          65      Average_Intensity 0.027059500    1
## 53                 0           0                   <NA> 0.000000000   -1
## 54                66          67           Eccentricity 0.923785000    1
## 55                 0           0                   <NA> 0.000000000   -1
## 56                 0           0                   <NA> 0.000000000   -1
## 57                 0           0                   <NA> 0.000000000   -1
## 58                 0           0                   <NA> 0.000000000   -1
## 59                 0           0                   <NA> 0.000000000   -1
## 60                68          69              Lobedness 0.117375000    1
## 61                70          71 Maximal_Indentation_Depth 0.039493500    1
## 62                 0           0                   <NA> 0.000000000   -1
## 63                 0           0                   <NA> 0.000000000   -1
## 64                 0           0                   <NA> 0.000000000   -1
## 65                 0           0                   <NA> 0.000000000   -1
## 66                72          73 Maximal_Indentation_Depth 0.009864600    1
## 67                 0           0                   <NA> 0.000000000   -1
## 68                74          75           Third_moment 0.003186600    1
## 69                76          77           Third_moment 0.003503350    1
## 70                78          79               Solidity 0.955745000    1
## 71                 0           0                   <NA> 0.000000000   -1
## 72                 0           0                   <NA> 0.000000000   -1
## 73                 0           0                   <NA> 0.000000000   -1
## 74                 0           0                   <NA> 0.000000000   -1
## 75                80          81               Solidity 0.954375000    1
## 76                 0           0                   <NA> 0.000000000   -1
## 77                82          83              Lobedness 0.240385000    1
## 78                 0           0                   <NA> 0.000000000   -1
## 79                 0           0                   <NA> 0.000000000   -1
## 80                84          85      Isoperimetric_Factor 0.607295000    1
## 81                 0           0                   <NA> 0.000000000   -1
## 82                86          87           Third_moment 0.010190000    1
## 83                88          89             Elongation 0.442270000    1
## 84                 0           0                   <NA> 0.000000000   -1
## 85                 0           0                   <NA> 0.000000000   -1
## 86                 0           0                   <NA> 0.000000000   -1
## 87                 0           0                   <NA> 0.000000000   -1
## 88                90          91       Average_Contrast 0.168315000    1
## 89                 0           0                   <NA> 0.000000000   -1
## 90                 0           0                   <NA> 0.000000000   -1
## 91                92          93    Stochastic_Convexity 0.980700000    1
## 92                 0           0                   <NA> 0.000000000   -1
## 93                 0           0                   <NA> 0.000000000   -1
##                   prediction
## 1                       <NA>
## 2                       <NA>
## 3                       <NA>
## 4               Acer palmatum
## 5                       <NA>
## 6              Podocarpus sp.
## 7          Pseudosasa japonica
## 8                       <NA>
## 9                       <NA>
## 10                Quercus suber
## 11                      <NA>
```

```
## 12                      <NA>
## 13                      <NA>
## 14                      <NA>
## 15         Buxus sempervirens
## 16               Geranium sp.
## 17               Populus alba
## 18                      <NA>
## 19                      <NA>
## 20         Crataegus monogyna
## 21 Ilex perado ssp. azorica
## 22                      <NA>
## 23                      <NA>
## 24                      <NA>
## 25                      <NA>
## 26                      <NA>
## 27                      <NA>
## 28                      <NA>
## 29                      <NA>
## 30                      <NA>
## 31                      <NA>
## 32                      <NA>
## 33       Magnolia soulangeana
## 34                Erodium sp.
## 35                      <NA>
## 36                      <NA>
## 37               Hydrangea sp.
## 38           Corylus avellana
## 39            Acca sellowiana
## 40 Ilex perado ssp. azorica
## 41            Salix atrocinera
## 42                      <NA>
## 43                      <NA>
## 44            Nerium oleander
## 45                      <NA>
## 46        Magnolia grandiflora
## 47                      <NA>
## 48                      <NA>
## 49            Arisarum vulgare
## 50                      <NA>
## 51            Acca sellowiana
## 52                      <NA>
## 53            Primula vulgaris
## 54                      <NA>
## 55                 Celtis sp.
## 56             Podocarpus sp.
## 57          Pseudosasa japonica
## 58            Castanea sativa
## 59       Magnolia soulangeana
## 60                      <NA>
## 61                      <NA>
## 62          Euonymus japonicus
## 63          Bougainvillea sp.
## 64            Acca sellowiana
## 65            Salix atrocinera
```

```
## 66                     <NA>
## 67            Quercus robur
## 68                     <NA>
## 69                     <NA>
## 70                     <NA>
## 71            Quercus robur
## 72           Castanea sativa
## 73      Magnolia soulangeana
## 74                Alnus sp.
## 75                     <NA>
## 76       Crataegus monogyna
## 77                     <NA>
## 78           Ilex aquifolium
## 79        Euonymus japonicus
## 80                     <NA>
## 81         Bougainvillea sp.
## 82                     <NA>
## 83                     <NA>
## 84             Urtica dioica
## 85          Betula pubescens
## 86          Betula pubescens
## 87            Populus nigra
## 88                     <NA>
## 89             Populus alba
## 90          Betula pubescens
## 91                     <NA>
## 92           Tilia tomentosa
## 93          Arisarum vulgare
```

```
MDSplot(model, train$Species)
```
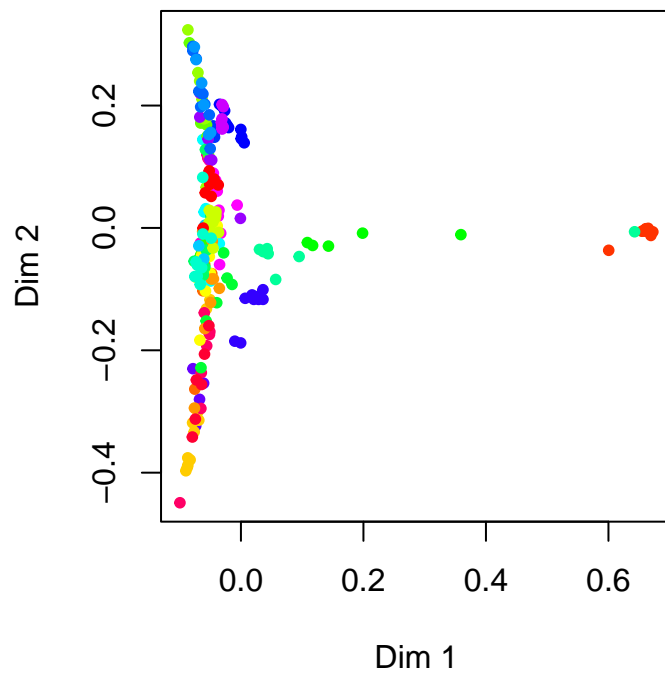
Here is the end of this tuturial. Down belong to another tutorial.

We know want to plot the out_of_bag rate and the error rate for each species in function of the numbers of tree in our random forest. We first put our model data in form of 2 columns(tree, error).

```
clas<-c("Quercus suber" ,"Salix atrocinera","Populus nigra","Alnus sp.","Quercus robur","Crataegus monog

err<-c(model$err.rate[,"OOB"])
for (i in clas) err<-c(err,model$err.rate[,i])

oob.error.data <- data.frame(Trees=rep(1:nrow(model$err.rate), times=31),Type=rep(c("OOB",clas), each=n
str(oob.error.data)
```

```
## 'data.frame':    6200 obs. of  3 variables:
##  $ Trees: int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Type : chr  "OOB" "OOB" "OOB" "OOB" ...
##  $ Error: num  0.44 0.445 0.489 0.507 0.521 ...
```

```
#head(oob.error.data)
```

Know we do the plot.

```
ggplot(data=oob.error.data, aes(x=Trees, y=Error)) + geom_line(aes(color=Type))
```

```
## Warning: Removed 1 row containing missing values (`geom_line()`).
```
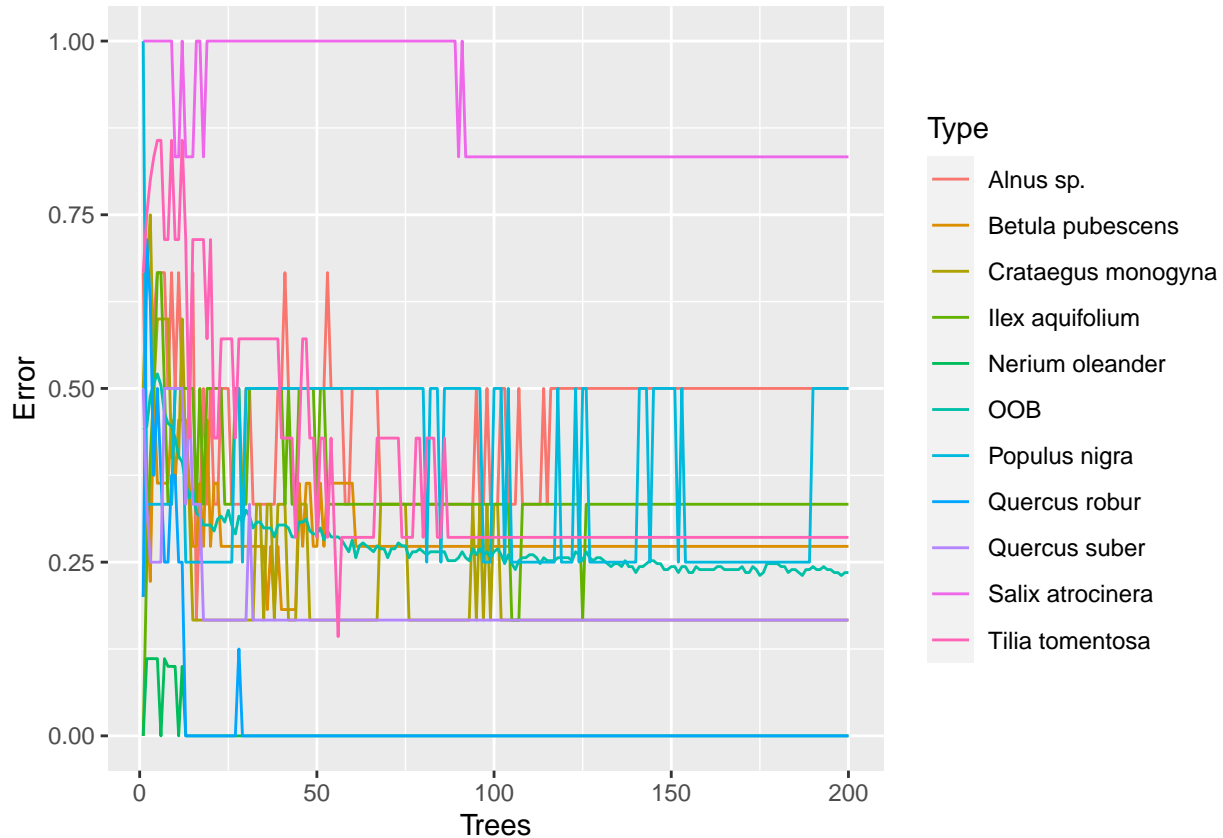


```
# ggsave("oob_error_rate_1000_trees.pdf")
```

```
clas<-c("Quercus suber" ,"Salix atrocinera","Populus nigra","Alnus sp.","Quercus robur","Crataegus monog
```

```
err<-c(model$err.rate[,"OOB"])
for (i in clas) err<-c(err,model$err.rate[,i])

oob.error.data <- data.frame(Trees=rep(1:nrow(model$err.rate), times=11),Type=rep(c("OOB",clas), each=n
ggplot(data=oob.error.data, aes(x=Trees, y=Error)) + geom_line(aes(color=Type))
```
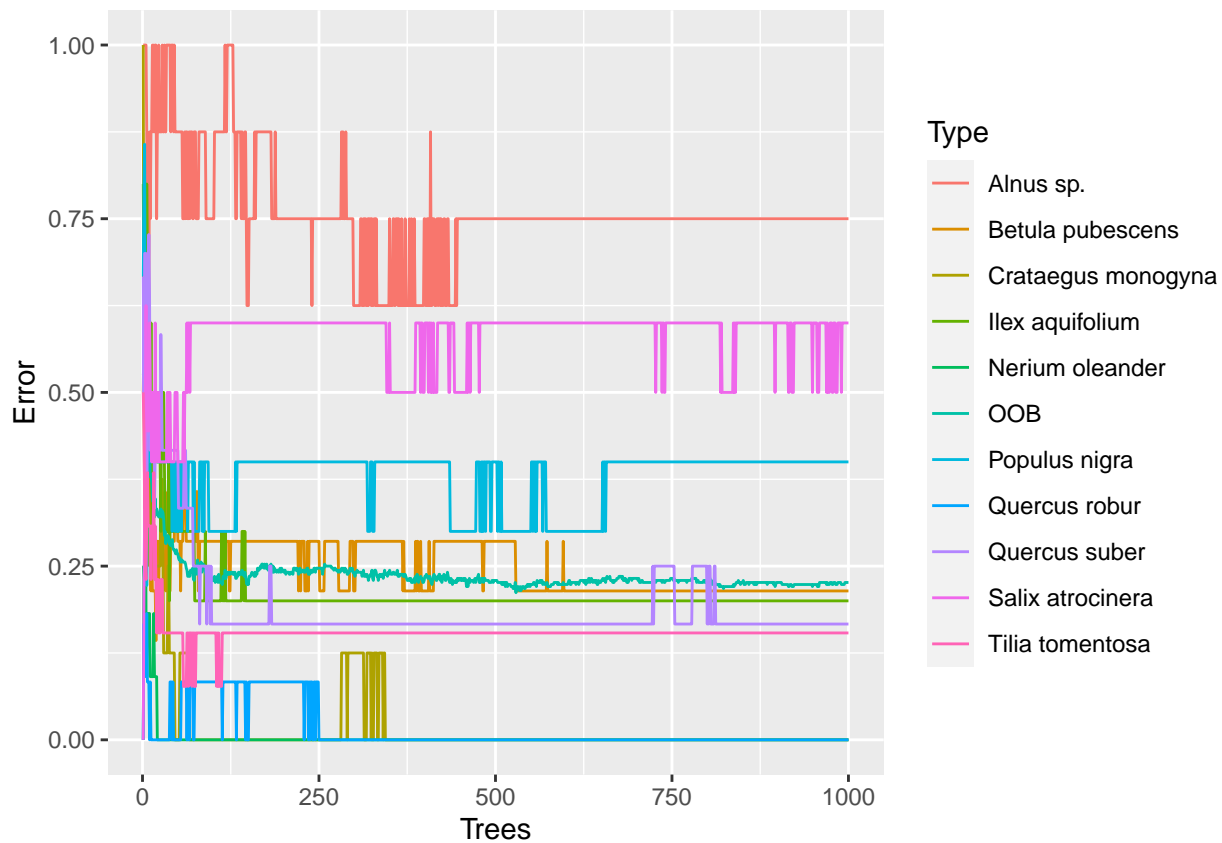


```
model <- randomForest(Species ~ ., data=dat, ntree=1000, proximity=TRUE)

clas<-c("Quercus suber" ,"Salix atrocinera","Populus nigra","Alnus sp.","Quercus robur","Crataegus monog

err<-c(model$err.rate[,"OOB"])
for (i in clas) err<-c(err,model$err.rate[,i])

oob.error.data <- data.frame(Trees=rep(1:nrow(model$err.rate), times=11),Type=rep(c("OOB",clas), each=n
ggplot(data=oob.error.data, aes(x=Trees, y=Error)) + geom_line(aes(color=Type))
```

```
## If we want to compare this random forest to others with different values for
## mtry (to control how many variables are considered at each step)...
oob.values <- vector(length=10)
for(i in 1:10) {
  temp.model <- randomForest(Species ~ ., data=dat, mtry=i, ntree=1000)
  oob.values[i] <- temp.model$err.rate[nrow(temp.model$err.rate),1]
}
oob.values
```

```
##  [1] 0.2441176 0.2205882 0.2205882 0.2235294 0.2176471 0.2235294 0.2176471
##  [8] 0.2235294 0.2205882 0.2264706
```

```
model <- randomForest(Species ~ ., data=dat,mtry=2, ntree=1000, proximity=TRUE)

clas<-c("Quercus suber" ,"Salix atrocinera")

err<-c(model$err.rate[,"OOB"])
for (i in clas) err<-c(err,model$err.rate[,i])

oob.error.data <- data.frame(Trees=rep(1:nrow(model$err.rate), times=3),Type=rep(c("OOB",clas), each=nro
ggplot(data=oob.error.data, aes(x=Trees, y=Error)) + geom_line(aes(color=Type))
```

```
attributes(model)
```
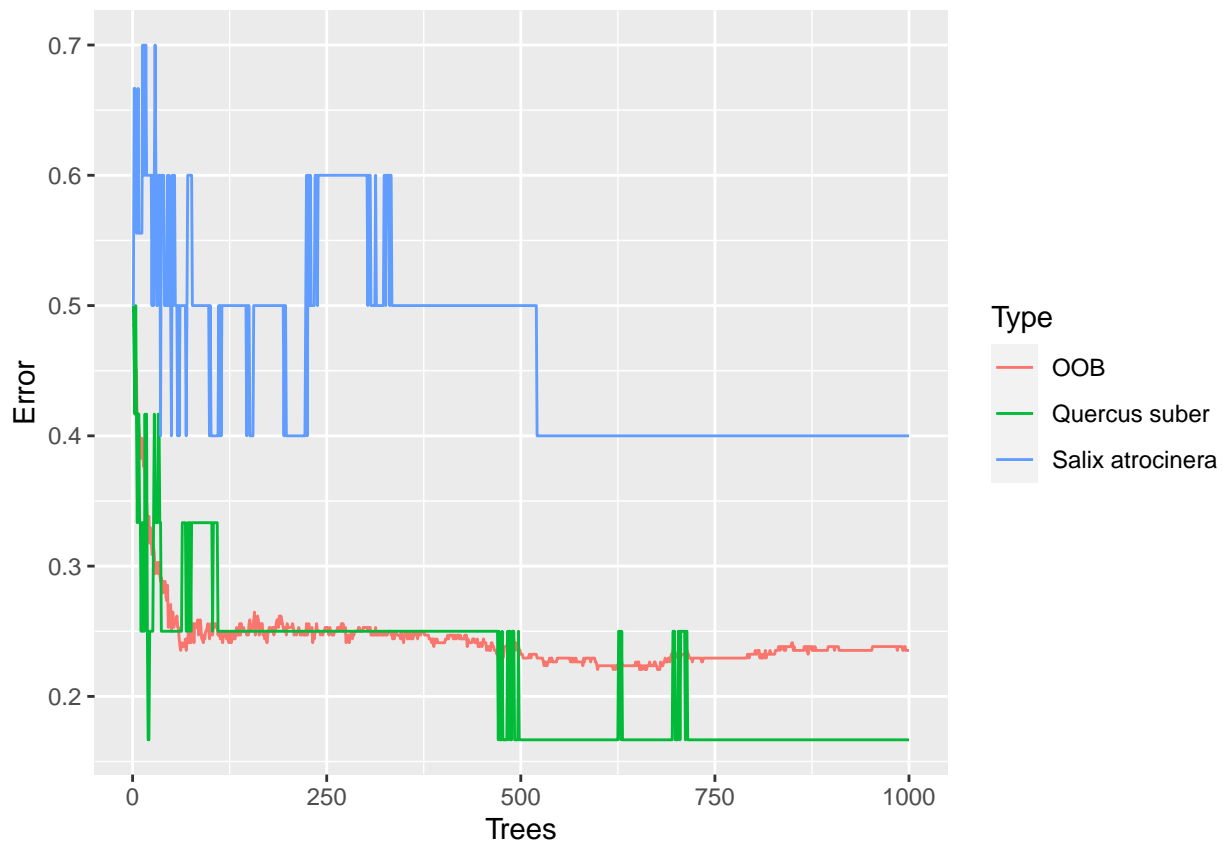
```
## $names
##  [1] "call"           "type"           "predicted"      "err.rate"
##  [5] "confusion"      "votes"          "oob.times"      "classes"
##  [9] "importance"     "importanceSD"   "localImportance" "proximity"
## [13] "ntree"          "mtry"           "forest"         "y"
## [17] "test"           "inbag"          "terms"
##
## $class
## [1] "randomForest.formula" "randomForest"
```

```
model$confusion
```

##	Acca sellowiana	Acer palmatum	Alnus sp.
## Acca sellowiana	3	0	0
## Acer palmatum	0	16	0
## Alnus sp.	0	0	2
## Arisarum vulgare	0	0	0
## Betula pubescens	0	0	0
## Bougainvillea sp.	0	0	1
## Buxus sempervirens	0	0	0
## Castanea sativa	1	0	0
## Celtis sp.	0	0	0
## Corylus avellana	0	0	0
## Crataegus monogyna	0	0	0
## Erodium sp.	0	0	0
## Euonymus japonicus	1	0	0

```
## Geranium sp.                                0               2              0
## Hydrangea sp.                               0               0              0
## Ilex aquifolium                             1               0              0
## Ilex perado ssp. azorica                    1               0              0
## Magnolia grandiflora                        0               0              0
## Magnolia soulangeana                        0               0              0
## Nerium oleander                             0               0              0
## Podocarpus sp.                              0               0              0
## Populus alba                                0               0              0
## Populus nigra                               0               0              0
## Primula vulgaris                            0               0              0
## Pseudosasa japonica                         0               0              0
## Quercus robur                               0               0              0
## Quercus suber                               0               0              0
## Salix atrocinera                            3               0              0
## Tilia tomentosa                             0               0              0
## Urtica dioica                               0               0              0
##                            Arisarum vulgare Betula pubescens Bougainvillea sp.
## Acca sellowiana                           0               0                 0
## Acer palmatum                             0               0                 0
## Alnus sp.                                 0               1                 2
## Arisarum vulgare                          9               0                 0
## Betula pubescens                          0              10                 0
## Bougainvillea sp.                         0               1                 9
## Buxus sempervirens                        0               0                 0
## Castanea sativa                           0               0                 0
## Celtis sp.                                0               0                 0
## Corylus avellana                          0               0                 0
## Crataegus monogyna                        0               0                 0
## Erodium sp.                               0               0                 0
## Euonymus japonicus                        0               0                 1
## Geranium sp.                              0               0                 0
## Hydrangea sp.                             0               0                 0
## Ilex aquifolium                           0               0                 0
## Ilex perado ssp. azorica                  0               0                 0
## Magnolia grandiflora                      0               0                 0
## Magnolia soulangeana                      0               0                 0
## Nerium oleander                           0               0                 0
## Podocarpus sp.                            0               0                 0
## Populus alba                              0               0                 0
## Populus nigra                             1               1                 1
## Primula vulgaris                          0               0                 0
## Pseudosasa japonica                       0               0                 0
## Quercus robur                             0               0                 0
## Quercus suber                             0               0                 0
## Salix atrocinera                          0               0                 0
## Tilia tomentosa                           0               1                 0
## Urtica dioica                             0               0                 1
##                            Buxus sempervirens Castanea sativa Celtis sp.
## Acca sellowiana                             0               1          0
## Acer palmatum                               0               0          0
## Alnus sp.                                   0               0          0
## Arisarum vulgare                            0               0          0
## Betula pubescens                            0               0          0
```

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```
## Bougainvillea sp.                      0                0               0
## Buxus sempervirens                    12                0               0
## Castanea sativa                        0                9               0
## Celtis sp.                             0                0               9
## Corylus avellana                       0                0               0
## Crataegus monogyna                     0                0               0
## Erodium sp.                            0                0               0
## Euonymus japonicus                     0                0               0
## Geranium sp.                           0                0               0
## Hydrangea sp.                          0                0               0
## Ilex aquifolium                        0                0               2
## Ilex perado ssp. azorica               0                0               0
## Magnolia grandiflora                   0                0               0
## Magnolia soulangeana                   0                3               2
## Nerium oleander                        0                0               0
## Podocarpus sp.                         0                0               0
## Populus alba                           0                0               0
## Populus nigra                          0                0               0
## Primula vulgaris                       0                0               1
## Pseudosasa japonica                    0                0               0
## Quercus robur                          0                0               0
## Quercus suber                          1                0               0
## Salix atrocinera                       0                0               0
## Tilia tomentosa                        0                0               0
## Urtica dioica                          0                0               0
##                          Corylus avellana Crataegus monogyna Erodium sp.
## Acca sellowiana                         0                  0           0
## Acer palmatum                           0                  0           0
## Alnus sp.                               0                  0           0
## Arisarum vulgare                        0                  0           0
## Betula pubescens                        0                  0           0
## Bougainvillea sp.                       0                  0           0
## Buxus sempervirens                      0                  0           0
## Castanea sativa                         0                  0           0
## Celtis sp.                              0                  0           0
## Corylus avellana                        8                  0           0
## Crataegus monogyna                      0                  8           0
## Erodium sp.                             0                  0          11
## Euonymus japonicus                      2                  0           0
## Geranium sp.                            0                  0           0
## Hydrangea sp.                           2                  0           0
## Ilex aquifolium                         0                  0           0
## Ilex perado ssp. azorica                0                  0           0
## Magnolia grandiflora                    0                  0           0
## Magnolia soulangeana                    0                  0           0
## Nerium oleander                         0                  0           0
## Podocarpus sp.                          0                  0           0
## Populus alba                            0                  0           0
## Populus nigra                           0                  0           1
## Primula vulgaris                        0                  1           0
## Pseudosasa japonica                     0                  0           0
## Quercus robur                           0                  0           0
## Quercus suber                           1                  0           0
## Salix atrocinera                        1                  0           0
```

```
## Tilia tomentosa                              0                0          0
## Urtica dioica                                0                0          0
##                          Euonymus japonicus Geranium sp. Hydrangea sp.
## Acca sellowiana                         0            0             0
## Acer palmatum                           0            0             0
## Alnus sp.                               1            0             0
## Arisarum vulgare                        0            0             0
## Betula pubescens                        0            0             0
## Bougainvillea sp.                       1            0             0
## Buxus sempervirens                      0            0             0
## Castanea sativa                         0            0             0
## Celtis sp.                              0            0             0
## Corylus avellana                        1            0             2
## Crataegus monogyna                      0            0             0
## Erodium sp.                             0            0             0
## Euonymus japonicus                      7            0             0
## Geranium sp.                            0            8             0
## Hydrangea sp.                           0            0             8
## Ilex aquifolium                         0            0             0
## Ilex perado ssp. azorica                1            0             1
## Magnolia grandiflora                    0            0             0
## Magnolia soulangeana                    0            0             0
## Nerium oleander                         0            0             0
## Podocarpus sp.                          0            0             0
## Populus alba                            0            0             0
## Populus nigra                           0            0             0
## Primula vulgaris                        0            0             0
## Pseudosasa japonica                     0            0             0
## Quercus robur                           0            0             0
## Quercus suber                           0            0             0
## Salix atrocinera                        0            0             0
## Tilia tomentosa                         0            0             0
## Urtica dioica                           0            0             0
##                          Ilex aquifolium Ilex perado ssp. azorica
## Acca sellowiana                       0                        1
## Acer palmatum                         0                        0
## Alnus sp.                             0                        1
## Arisarum vulgare                      0                        0
## Betula pubescens                      1                        0
## Bougainvillea sp.                     0                        0
## Buxus sempervirens                    0                        0
## Castanea sativa                       0                        0
## Celtis sp.                            1                        0
## Corylus avellana                      0                        2
## Crataegus monogyna                    0                        0
## Erodium sp.                           0                        0
## Euonymus japonicus                    0                        0
## Geranium sp.                          0                        0
## Hydrangea sp.                         0                        0
## Ilex aquifolium                       7                        0
## Ilex perado ssp. azorica              0                        7
## Magnolia grandiflora                  0                        0
## Magnolia soulangeana                  0                        0
## Nerium oleander                       0                        0
```

```
## Podocarpus sp.                       0                      0
## Populus alba                         0                      0
## Populus nigra                        0                      0
## Primula vulgaris                     1                      0
## Pseudosasa japonica                  0                      0
## Quercus robur                        0                      0
## Quercus suber                        0                      0
## Salix atrocinera                     0                      0
## Tilia tomentosa                      0                      0
## Urtica dioica                        0                      0
##                         Magnolia grandiflora Magnolia soulangeana
## Acca sellowiana                      0                      0
## Acer palmatum                        0                      0
## Alnus sp.                            0                      0
## Arisarum vulgare                     0                      0
## Betula pubescens                     0                      0
## Bougainvillea sp.                    0                      0
## Buxus sempervirens                   0                      0
## Castanea sativa                      0                      1
## Celtis sp.                           0                      1
## Corylus avellana                     0                      0
## Crataegus monogyna                   0                      0
## Erodium sp.                          0                      0
## Euonymus japonicus                   0                      0
## Geranium sp.                         0                      0
## Hydrangea sp.                        0                      0
## Ilex aquifolium                      0                      0
## Ilex perado ssp. azorica             0                      0
## Magnolia grandiflora                 8                      2
## Magnolia soulangeana                 1                      6
## Nerium oleander                      0                      0
## Podocarpus sp.                       0                      0
## Populus alba                         0                      0
## Populus nigra                        0                      0
## Primula vulgaris                     0                      1
## Pseudosasa japonica                  0                      0
## Quercus robur                        0                      0
## Quercus suber                        0                      0
## Salix atrocinera                     0                      0
## Tilia tomentosa                      0                      0
## Urtica dioica                        0                      0
##                         Nerium oleander Podocarpus sp. Populus alba
## Acca sellowiana                      0              0            0
## Acer palmatum                        0              0            0
## Alnus sp.                            0              0            0
## Arisarum vulgare                     0              0            0
## Betula pubescens                     0              0            0
## Bougainvillea sp.                    0              0            0
## Buxus sempervirens                   0              0            0
## Castanea sativa                      0              0            0
## Celtis sp.                           0              0            0
## Corylus avellana                     0              0            0
## Crataegus monogyna                   0              0            0
## Erodium sp.                          0              0            0
```

```
## Euonymus japonicus                              0             0             0
## Geranium sp.                                    0             0             0
## Hydrangea sp.                                   0             0             0
## Ilex aquifolium                                 0             0             0
## Ilex perado ssp. azorica                        0             0             0
## Magnolia grandiflora                            0             0             0
## Magnolia soulangeana                            0             0             0
## Nerium oleander                                11             0             0
## Podocarpus sp.                                  0             9             0
## Populus alba                                    0             0            10
## Populus nigra                                   0             0             0
## Primula vulgaris                                0             0             0
## Pseudosasa japonica                             0             2             0
## Quercus robur                                   0             0             0
## Quercus suber                                   0             0             0
## Salix atrocinera                                0             0             0
## Tilia tomentosa                                 0             0             0
## Urtica dioica                                   0             0             0
##                          Populus nigra Primula vulgaris Pseudosasa japonica
## Acca sellowiana                      0             0             0
## Acer palmatum                        0             0             0
## Alnus sp.                            0             0             0
## Arisarum vulgare                     0             0             0
## Betula pubescens                     1             0             0
## Bougainvillea sp.                    0             0             0
## Buxus sempervirens                   0             0             0
## Castanea sativa                      0             1             0
## Celtis sp.                           0             0             0
## Corylus avellana                     0             0             0
## Crataegus monogyna                   0             0             0
## Erodium sp.                          0             0             0
## Euonymus japonicus                   0             1             0
## Geranium sp.                         0             0             0
## Hydrangea sp.                        0             0             0
## Ilex aquifolium                      0             0             0
## Ilex perado ssp. azorica             0             0             0
## Magnolia grandiflora                 0             1             0
## Magnolia soulangeana                 0             0             0
## Nerium oleander                      0             0             0
## Podocarpus sp.                       0             0             2
## Populus alba                         0             0             0
## Populus nigra                        6             0             0
## Primula vulgaris                     0             7             0
## Pseudosasa japonica                  0             0             9
## Quercus robur                        0             0             0
## Quercus suber                        0             0             0
## Salix atrocinera                     0             0             0
## Tilia tomentosa                      0             0             0
## Urtica dioica                        0             0             0
##                          Quercus robur Quercus suber Salix atrocinera
## Acca sellowiana                      0             2             4
## Acer palmatum                        0             0             0
## Alnus sp.                            0             0             0
## Arisarum vulgare                     0             0             0
```

```
## Betula pubescens                        0              0              0
## Bougainvillea sp.                       0              1              0
## Buxus sempervirens                      0              0              0
## Castanea sativa                         0              0              0
## Celtis sp.                              0              0              1
## Corylus avellana                        0              0              0
## Crataegus monogyna                      0              0              0
## Erodium sp.                             0              0              0
## Euonymus japonicus                      0              0              0
## Geranium sp.                            0              0              0
## Hydrangea sp.                           0              1              0
## Ilex aquifolium                         0              0              0
## Ilex perado ssp. azorica                0              1              0
## Magnolia grandiflora                    0              0              0
## Magnolia soulangeana                    0              0              0
## Nerium oleander                         0              0              0
## Podocarpus sp.                          0              0              0
## Populus alba                            0              0              0
## Populus nigra                           0              0              0
## Primula vulgaris                        1              0              0
## Pseudosasa japonica                     0              0              0
## Quercus robur                          12              0              0
## Quercus suber                           0             10              0
## Salix atrocinera                        0              0              6
## Tilia tomentosa                         0              0              0
## Urtica dioica                           0              0              0
##                          Tilia tomentosa Urtica dioica class.error
## Acca sellowiana                        0              0  0.72727273
## Acer palmatum                          0              0  0.00000000
## Alnus sp.                              0              1  0.75000000
## Arisarum vulgare                       0              0  0.00000000
## Betula pubescens                       2              0  0.28571429
## Bougainvillea sp.                      0              0  0.30769231
## Buxus sempervirens                     0              0  0.00000000
## Castanea sativa                        0              0  0.25000000
## Celtis sp.                             0              0  0.25000000
## Corylus avellana                       0              0  0.38461538
## Crataegus monogyna                     0              0  0.00000000
## Erodium sp.                            0              0  0.00000000
## Euonymus japonicus                     0              0  0.41666667
## Geranium sp.                           0              0  0.20000000
## Hydrangea sp.                          0              0  0.27272727
## Ilex aquifolium                        0              0  0.30000000
## Ilex perado ssp. azorica               0              0  0.36363636
## Magnolia grandiflora                   0              0  0.27272727
## Magnolia soulangeana                   0              0  0.50000000
## Nerium oleander                        0              0  0.00000000
## Podocarpus sp.                         0              0  0.18181818
## Populus alba                           0              0  0.00000000
## Populus nigra                          0              0  0.40000000
## Primula vulgaris                       0              0  0.41666667
## Pseudosasa japonica                    0              0  0.18181818
## Quercus robur                          0              0  0.00000000
## Quercus suber                          0              0  0.16666667
```

```
## Salix atrocinera                              0            0  0.40000000
## Tilia tomentosa                              12            0  0.07692308
## Urtica dioica                                 0           11  0.08333333
```

```r
# Fit a random forest model
#model <- randomForest(x, y, ntree = 100, oob_prediction = TRUE)

# Collect OOB predictions
oob_predictions <- predict(model, data=dat[-1])#, type = "OOB")
#cm = table(dat[1:10,1], oob_predictions)
oob_predictions
```

```
##                        1                       2                       3
##          Corylus avellana           Quercus suber           Quercus suber
##                        4                       5                       6
##             Quercus suber           Quercus suber           Quercus suber
##                        7                       8                       9
##             Quercus suber           Quercus suber           Quercus suber
##                       10                      11                      12
##       Buxus sempervirens           Quercus suber           Quercus suber
##                       13                      14                      15
##          Salix atrocinera        Salix atrocinera         Acca sellowiana
##                       16                      17                      18
##          Acca sellowiana        Salix atrocinera        Salix atrocinera
##                       19                      20                      21
##          Acca sellowiana        Salix atrocinera        Salix atrocinera
##                       22                      23                      24
##          Corylus avellana         Arisarum vulgare       Bougainvillea sp.
##                       25                      26                      27
##             Populus nigra         Betula pubescens           Populus nigra
##                       28                      29                      30
##             Populus nigra           Populus nigra             Erodium sp.
##                       31                      32                      33
##             Populus nigra           Populus nigra           Urtica dioica
##                       34                      35                      36
##        Bougainvillea sp.               Alnus sp.        Betula pubescens
##                       37                      38                      39
## Ilex perado ssp. azorica               Alnus sp.       Bougainvillea sp.
##                       40                      41                      42
##        Euonymus japonicus           Quercus robur           Quercus robur
##                       43                      44                      45
##             Quercus robur           Quercus robur           Quercus robur
##                       46                      47                      48
##             Quercus robur           Quercus robur           Quercus robur
##                       49                      50                      51
##             Quercus robur           Quercus robur           Quercus robur
##                       52                      53                      54
##             Quercus robur      Crataegus monogyna      Crataegus monogyna
##                       55                      56                      57
##       Crataegus monogyna      Crataegus monogyna      Crataegus monogyna
##                       58                      59                      60
##       Crataegus monogyna      Crataegus monogyna      Crataegus monogyna
##                       61                      62                      63
##            Ilex aquifolium         Ilex aquifolium              Celtis sp.
##                       64                      65                      66
```

```
##           Ilex aquifolium           Ilex aquifolium           Ilex aquifolium
##                        67                        68                        69
##                Celtis sp.           Acca sellowiana           Ilex aquifolium
##                        70                        71                        72
##           Ilex aquifolium           Nerium oleander           Nerium oleander
##                        73                        74                        75
##           Nerium oleander           Nerium oleander           Nerium oleander
##                        76                        77                        78
##           Nerium oleander           Nerium oleander           Nerium oleander
##                        79                        80                        81
##           Nerium oleander           Nerium oleander           Nerium oleander
##                        82                        83                        84
##          Betula pubescens          Betula pubescens          Betula pubescens
##                        85                        86                        87
##           Tilia tomentosa          Betula pubescens          Betula pubescens
##                        88                        89                        90
##           Tilia tomentosa             Populus nigra          Betula pubescens
##                        91                        92                        93
##          Betula pubescens           Ilex aquifolium          Betula pubescens
##                        94                        95                        96
##          Betula pubescens          Betula pubescens           Tilia tomentosa
##                        97                        98                        99
##           Tilia tomentosa          Betula pubescens           Tilia tomentosa
##                       100                       101                       102
##           Tilia tomentosa           Tilia tomentosa           Tilia tomentosa
##                       103                       104                       105
##           Tilia tomentosa           Tilia tomentosa           Tilia tomentosa
##                       106                       107                       108
##           Tilia tomentosa           Tilia tomentosa           Tilia tomentosa
##                       109                       110                       111
##             Acer palmatum             Acer palmatum             Acer palmatum
##                       112                       113                       114
##             Acer palmatum             Acer palmatum             Acer palmatum
##                       115                       116                       117
##             Acer palmatum             Acer palmatum             Acer palmatum
##                       118                       119                       120
##             Acer palmatum             Acer palmatum             Acer palmatum
##                       121                       122                       123
##             Acer palmatum             Acer palmatum             Acer palmatum
##                       124                       125                       126
##             Acer palmatum                Celtis sp.     Magnolia soulangeana
##                       127                       128                       129
##           Ilex aquifolium                Celtis sp.                Celtis sp.
##                       130                       131                       132
##                Celtis sp.           Salix atrocinera                Celtis sp.
##                       133                       134                       135
##                Celtis sp.                Celtis sp.                Celtis sp.
##                       136                       137                       138
##                Celtis sp.         Corylus avellana         Corylus avellana
##                       139                       140                       141
##          Corylus avellana         Euonymus japonicus         Corylus avellana
##                       142                       143                       144
##          Corylus avellana Ilex perado ssp. azorica             Hydrangea sp.
##                       145                       146                       147
```

```
##      Corylus avellana Ilex perado ssp. azorica       Corylus avellana
##                   148                          149                    150
##        Hydrangea sp.             Corylus avellana         Castanea sativa
##                   151                          152                    153
##       Castanea sativa              Castanea sativa     Magnolia soulangeana
##                   154                          155                    156
##        Acca sellowiana             Castanea sativa         Castanea sativa
##                   157                          158                    159
##        Primula vulgaris            Castanea sativa         Castanea sativa
##                   160                          161                    162
##       Castanea sativa              Castanea sativa            Populus alba
##                   163                          164                    165
##          Populus alba                 Populus alba            Populus alba
##                   166                          167                    168
##          Populus alba                 Populus alba            Populus alba
##                   169                          170                    171
##          Populus alba                 Populus alba            Populus alba
##                   172                          173                    174
##        Primula vulgaris           Primula vulgaris     Magnolia soulangeana
##                   175                          176                    177
##            Celtis sp.                Quercus robur         Primula vulgaris
##                   178                          179                    180
##        Primula vulgaris           Primula vulgaris          Ilex aquifolium
##                   181                          182                    183
##        Primula vulgaris         Crataegus monogyna         Primula vulgaris
##                   184                          185                    186
##           Erodium sp.                  Erodium sp.              Erodium sp.
##                   187                          188                    189
##           Erodium sp.                  Erodium sp.              Erodium sp.
##                   190                          191                    192
##           Erodium sp.                  Erodium sp.              Erodium sp.
##                   193                          194                    195
##           Erodium sp.                  Erodium sp.         Bougainvillea sp.
##                   196                          197                    198
##      Bougainvillea sp.          Euonymus japonicus       Bougainvillea sp.
##                   199                          200                    201
##            Alnus sp.              Betula pubescens       Bougainvillea sp.
##                   202                          203                    204
##          Quercus suber           Bougainvillea sp.       Bougainvillea sp.
##                   205                          206                    207
##      Bougainvillea sp.          Bougainvillea sp.        Bougainvillea sp.
##                   208                          209                    210
##        Arisarum vulgare           Arisarum vulgare         Arisarum vulgare
##                   211                          212                    213
##        Arisarum vulgare           Arisarum vulgare         Arisarum vulgare
##                   214                          215                    216
##        Arisarum vulgare           Arisarum vulgare         Arisarum vulgare
##                   217                          218                    219
##       Corylus avellana            Acca sellowiana       Euonymus japonicus
##                   220                          221                    222
##      Bougainvillea sp.          Euonymus japonicus       Euonymus japonicus
##                   223                          224                    225
##     Euonymus japonicus          Euonymus japonicus         Primula vulgaris
##                   226                          227                    228
```

```
##          Corylus avellana      Euonymus japonicus       Euonymus japonicus
##                     229                      230                      231
##      Euonymus japonicus Ilex perado ssp. azorica Ilex perado ssp. azorica
##                     232                      233                      234
## Ilex perado ssp. azorica Ilex perado ssp. azorica Ilex perado ssp. azorica
##                     235                      236                      237
##          Acca sellowiana Ilex perado ssp. azorica Ilex perado ssp. azorica
##                     238                      239                      240
##           Hydrangea sp.            Quercus suber      Magnolia soulangeana
##                     241                      242                      243
##               Celtis sp.     Magnolia soulangeana          Castanea sativa
##                     244                      245                      246
##          Castanea sativa     Magnolia soulangeana      Magnolia grandiflora
##                     247                      248                      249
##               Celtis sp.     Magnolia soulangeana          Castanea sativa
##                     250                      251                      252
##     Magnolia soulangeana     Magnolia soulangeana       Buxus sempervirens
##                     253                      254                      255
##       Buxus sempervirens       Buxus sempervirens       Buxus sempervirens
##                     256                      257                      258
##       Buxus sempervirens       Buxus sempervirens       Buxus sempervirens
##                     259                      260                      261
##       Buxus sempervirens       Buxus sempervirens       Buxus sempervirens
##                     262                      263                      264
##       Buxus sempervirens       Buxus sempervirens            Urtica dioica
##                     265                      266                      267
##            Urtica dioica            Urtica dioica            Urtica dioica
##                     268                      269                      270
##            Urtica dioica            Urtica dioica            Urtica dioica
##                     271                      272                      273
##            Urtica dioica            Urtica dioica            Urtica dioica
##                     274                      275                      276
##            Urtica dioica        Bougainvillea sp.           Podocarpus sp.
##                     277                      278                      279
##           Podocarpus sp.           Podocarpus sp.       Pseudosasa japonica
##                     280                      281                      282
##      Pseudosasa japonica           Podocarpus sp.           Podocarpus sp.
##                     283                      284                      285
##           Podocarpus sp.           Podocarpus sp.           Podocarpus sp.
##                     286                      287                      288
##           Podocarpus sp.          Acca sellowiana          Salix atrocinera
##                     289                      290                      291
##          Castanea sativa         Salix atrocinera          Acca sellowiana
##                     292                      293                      294
##          Acca sellowiana         Salix atrocinera         Salix atrocinera
##                     295                      296                      297
## Ilex perado ssp. azorica            Quercus suber            Quercus suber
##                     298                      299                      300
##           Hydrangea sp.            Hydrangea sp.            Hydrangea sp.
##                     301                      302                      303
##            Quercus suber         Corylus avellana            Hydrangea sp.
##                     304                      305                      306
##            Hydrangea sp.         Corylus avellana            Hydrangea sp.
##                     307                      308                      309
```

```
##             Hydrangea sp.                 Hydrangea sp.            Pseudosasa japonica
##                       310                           311                           312
##        Pseudosasa japonica           Pseudosasa japonica           Pseudosasa japonica
##                       313                           314                           315
##             Podocarpus sp.           Pseudosasa japonica           Pseudosasa japonica
##                       316                           317                           318
##        Pseudosasa japonica           Pseudosasa japonica           Pseudosasa japonica
##                       319                           320                           321
##             Podocarpus sp.          Magnolia grandiflora          Magnolia grandiflora
##                       322                           323                           324
##      Magnolia soulangeana          Magnolia grandiflora          Magnolia grandiflora
##                       325                           326                           327
##      Magnolia soulangeana          Magnolia grandiflora          Magnolia grandiflora
##                       328                           329                           330
##      Magnolia grandiflora          Magnolia grandiflora               Primula vulgaris
##                       331                           332                           333
##              Geranium sp.                  Geranium sp.                  Geranium sp.
##                       334                           335                           336
##              Geranium sp.                  Geranium sp.                  Geranium sp.
##                       337                           338                           339
##              Geranium sp.                  Geranium sp.                  Acer palmatum
##                       340
##              Acer palmatum
## 30 Levels: Acca sellowiana Acer palmatum Alnus sp. ... Urtica dioica
```

```r
# Save OOB predictions in a data frame
#oob_predictions_df <- data.frame(observation = 1:nrow(x), oob_prediction = oob_predictions)
```