Lab 9

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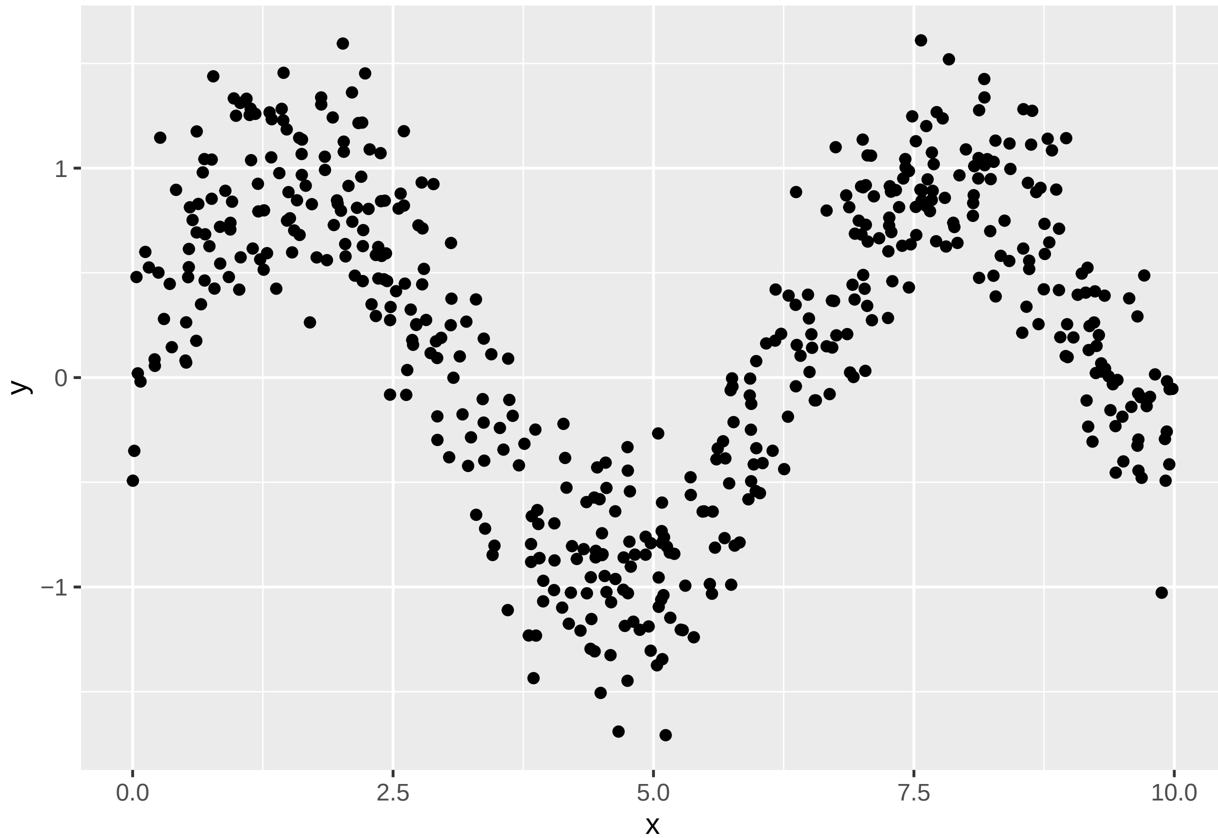
Here we will learn about trees, bagged trees and random forests. You can use the `YARF` package if it works, otherwise, use the `randomForest` package (the standard).

Let's take a look at the simulated sine curve data from practice lecture 12. Below is the code for the data generating process:

```
rm(list = ls())
n = 500
sigma = 0.3
x_min = 0
x_max = 10
f_x = function(x){sin(x)}
y_x = function(x, sigma){f_x(x) + rnorm(n, 0, sigma)}
x_train = runif(n, x_min, x_max)
y_train = y_x(x_train, sigma)
```

Plot an example dataset of size 500:

```
pacman::p_load(ggplot2)
ggplot(data.frame(x = x_train, y = y_train)) +
  geom_point(aes(x = x, y = y))
```

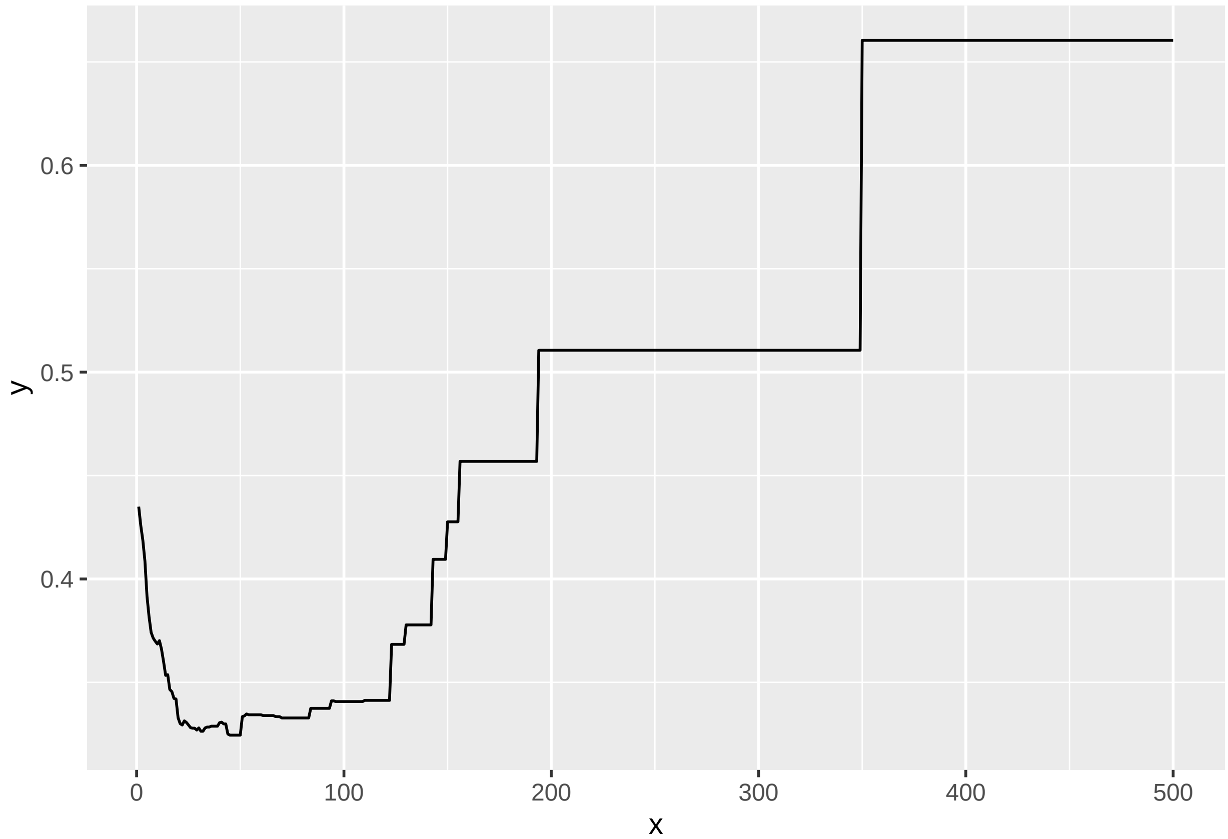


Create a test set of size 500 as well

```
x_test = runif(n, x_min, x_max)
y_test = y_x(x_test, sigma)
```

Locate the optimal node size hyperparameter for the regression tree model. I believe you can use `randomForest` here by setting `ntree = 1`, `replace = FALSE`, `sampsize = n` (`mtry` is already set to be 1 because there is only one feature) and then you can set `nodesize`. Plot node size by out of sample SE.

```
pacman::p_load(randomForest)

node_sizes = 1:n

se_by_node_sizes = array(NA, length(node_sizes))
for(i in 1:length(node_sizes)){
  rf_mod = randomForest(x = data.frame(x = x_train), y = y_train, ntree = 1, replace = FALSE, sampsize =
  y_hat_test = predict(rf_mod, data.frame(x = x_test))
  se_by_node_sizes[i] = sd(y_test - y_hat_test)
}

ggplot(data.frame(x = node_sizes, y = se_by_node_sizes)) +
  geom_line(aes(x = x, y = y))
```




```
  scale_x_reverse()
```

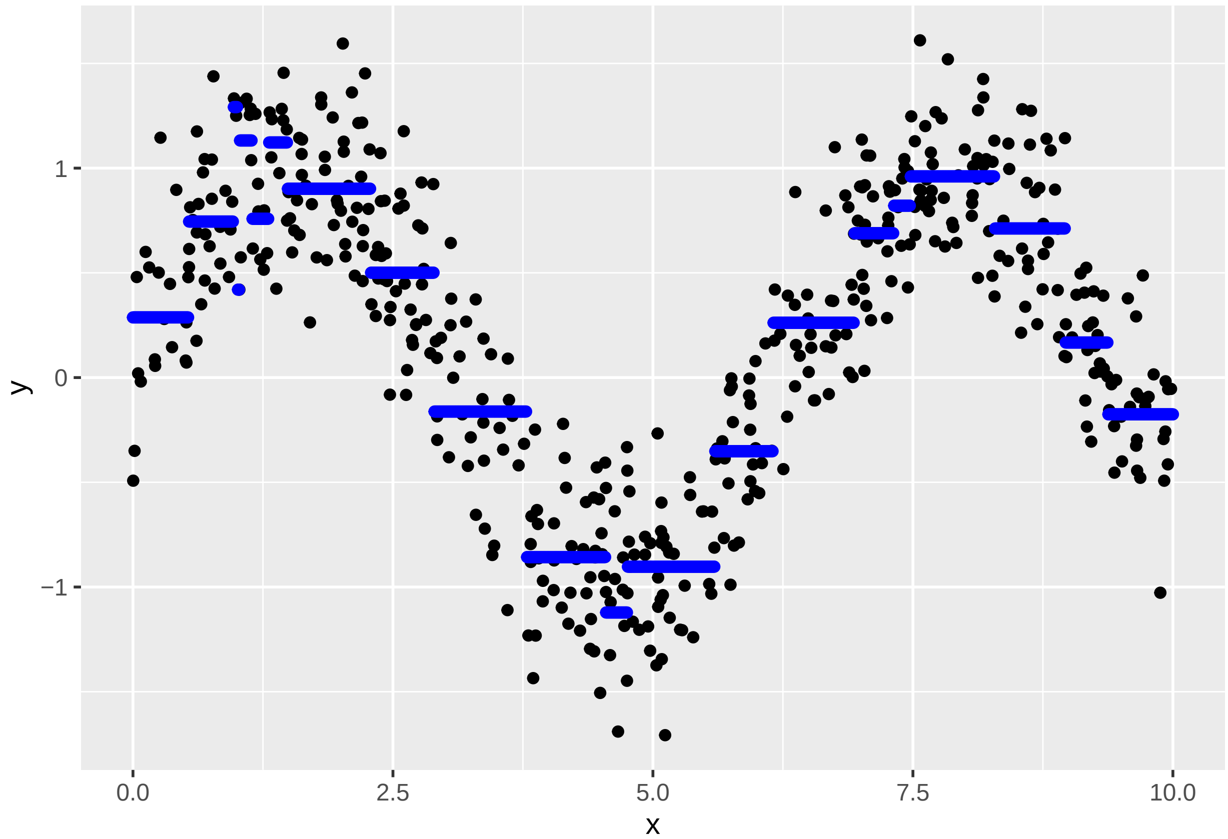
```
## <ScaleContinuousPosition>
##  Range:
##  Limits:    0 --    1
```

```
  which.min(se_by_node_sizes)
```

```
## [1] 45
```

Plot the regression tree model with the optimal node size.

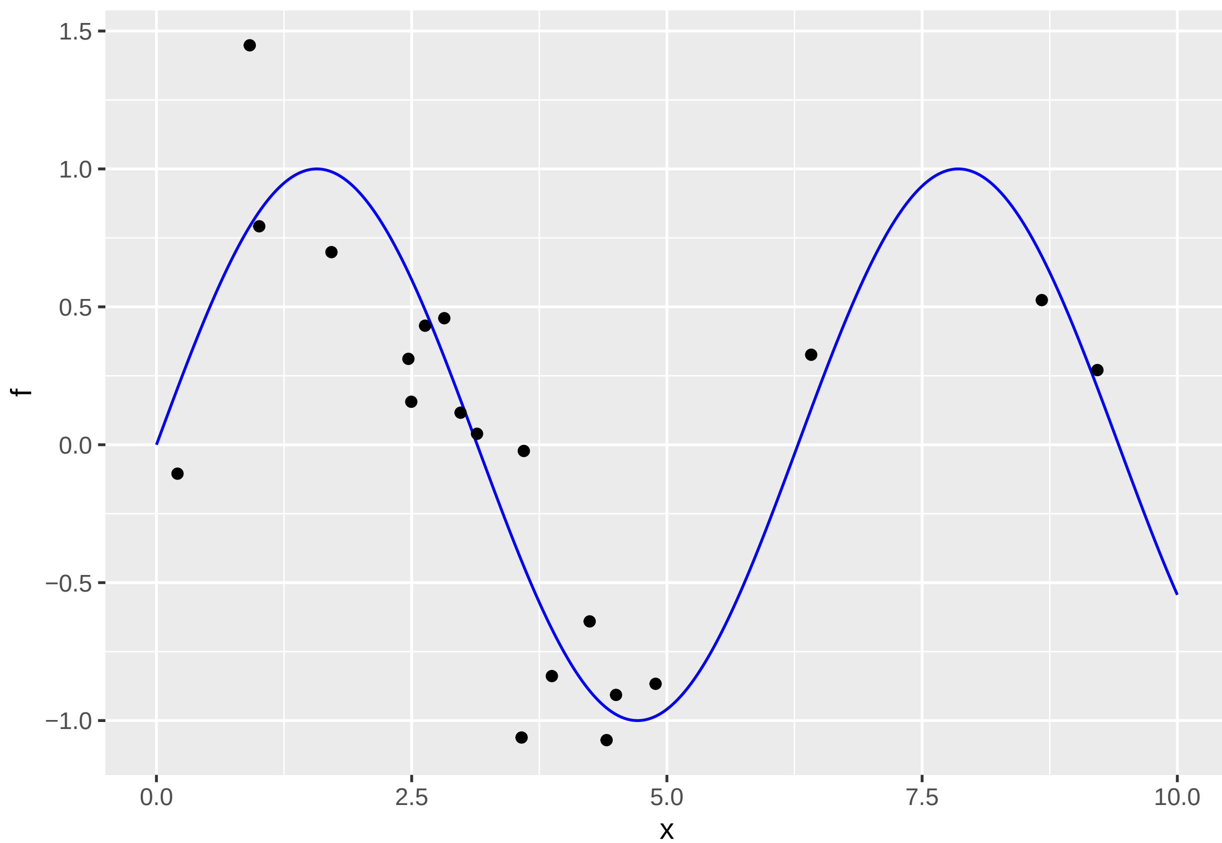
```
rf_mod = randomForest(x = data.frame(x = x_train), y = y_train, ntree = 1, replace = FALSE, sampsize = n
resolution = 0.01
x_grid = seq(from = x_min, to = x_max, by = resolution)
g_x = predict(rf_mod, data.frame(x = x_grid))

ggplot(data.frame(x = x_grid, y = g_x)) +
  aes(x = x, y = y) +
  geom_point(data = data.frame(x = x_train, y = y_train)) +
  geom_point(color = "blue")
```



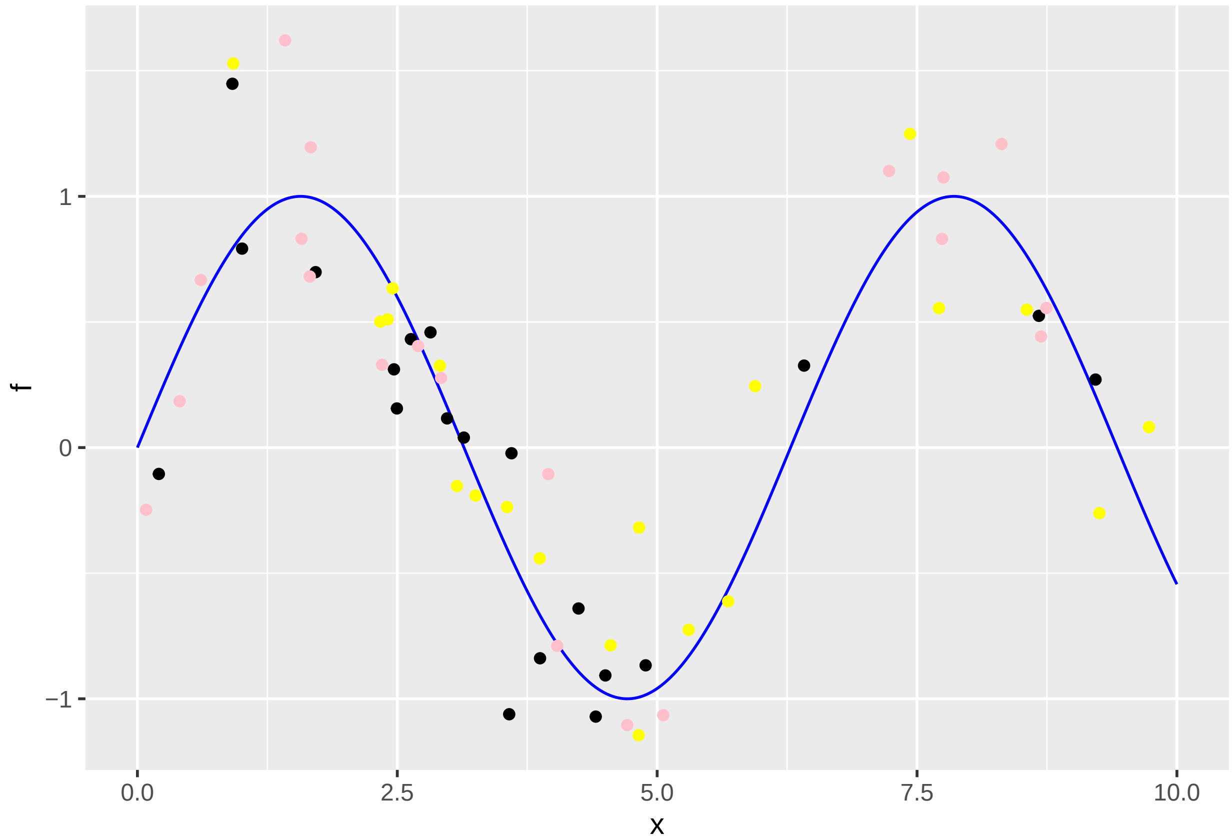
Provide the bias-variance decomposition of this DGP fit with this model. It is a lot of code, but it is in the practice lectures. If your three numbers don't add up within two significant digits, increase your resolution.

```
n_train = 20
n_test = 1000
Nsim = 1000

training_gs = matrix(NA, nrow = Nsim, ncol = 2)
x_training = matrix(NA, nrow = Nsim, ncol = n_train)
y_training = matrix(NA, nrow = Nsim, ncol = n_train)
all_oos_residuals = matrix(NA, nrow = Nsim, ncol = n_test)

for (nsim in 1 : Nsim){
  x_train = runif(n_train, x_min, x_max)
  delta_train = rnorm(n_train, 0, sigma)
  y_train = f_x(x_train) + delta_train
  x_training[nsim, ] = x_train
  y_training[nsim, ] = y_train


  g_model = lm(y_train ~ ., data.frame(x = x_train))
  training_gs[nsim, ] = coef(g_model)


  x_test = runif(n_test, x_min, x_max)
  delta_test = rnorm(n_test, 0, sigma)
```

```
  y_test = f_x(x_test) + delta_test
  y_hat_test = predict(g_model, data.frame(x = x_test))
  all_oos_residuals[nsim, ] = y_test - y_hat_test
}

pacman::p_load(ggplot2)
resolution = 10000
x = seq(x_min, x_max, length.out = resolution)
f_x_2 = data.frame(x = x, f = f_x(x))
ggplot(f_x_2, aes(x, f)) +
  geom_line(col = "blue") +
  geom_point(aes(x, y), data = data.frame(x = x_training[1, ], y = y_training[1, ]))
```



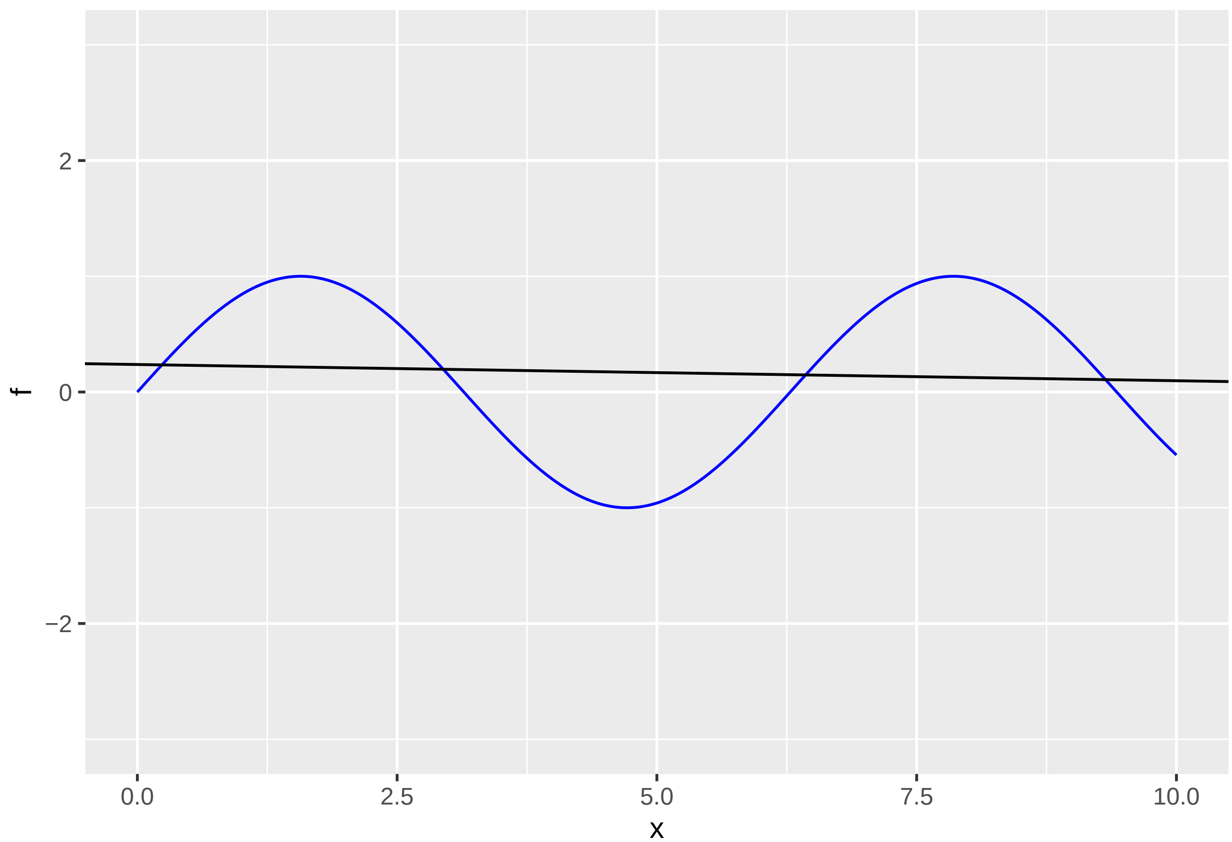

```
ggplot(f_x_2, aes(x, f)) +
  geom_line(col = "blue") +
  geom_point(aes(x, y), data = data.frame(x = x_training[1, ], y = y_training[1, ]), col = "black") +
  geom_point(aes(x, y), data = data.frame(x = x_training[2, ], y = y_training[2, ]), col = "yellow") +
  geom_point(aes(x, y), data = data.frame(x = x_training[3, ], y = y_training[3, ]), col = "pink")
```




```
MSE = mean(c(all_oos_residuals)^2)
MSE
```

```
## [1] 0.5843797
```

```
g_average = colMeans(training_gs)
ggplot(f_x_2, aes(x, f)) +
  geom_line(col = "blue") +
  geom_abline(intercept = g_average[1], slope = g_average[2], col = "black") +
  ylim(-3, 3)
```

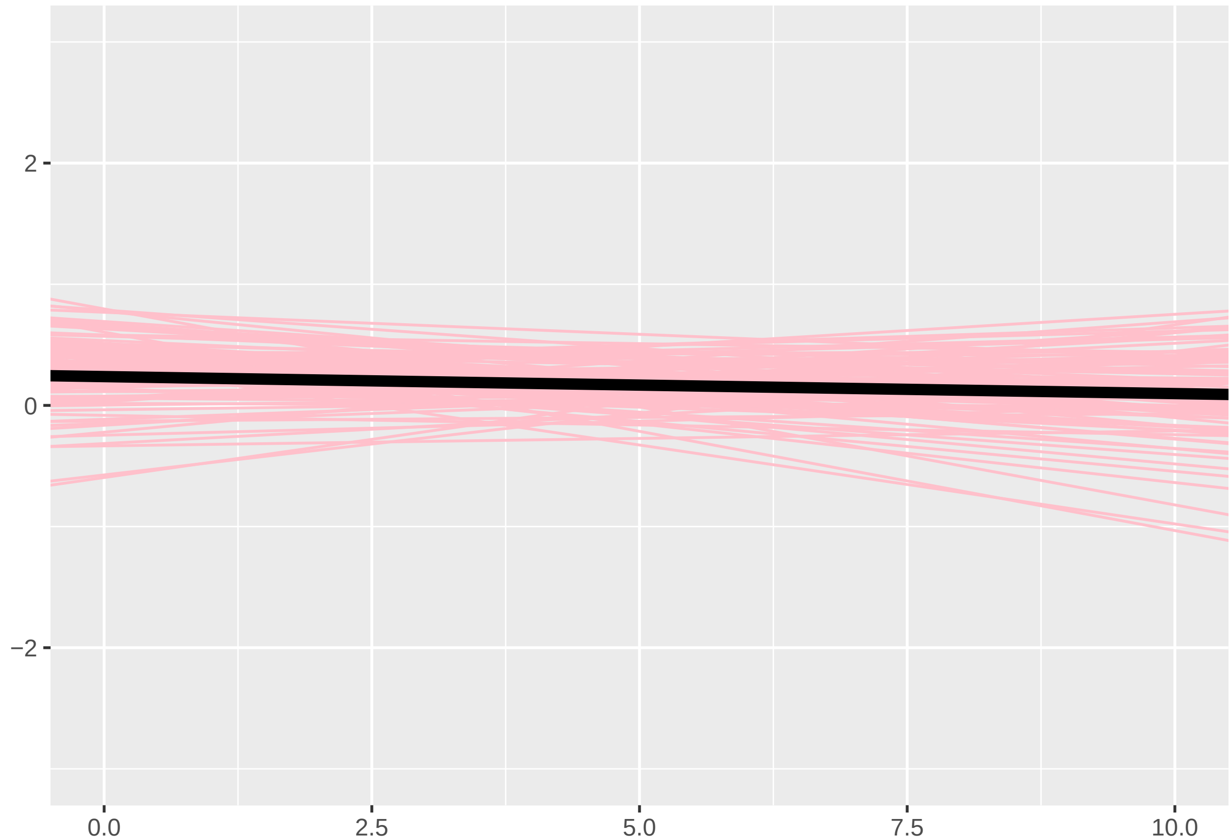



```
x = seq(x_min, x_max, length.out = resolution)
g_avg_x = g_average[1] + g_average[2] * x
f = sin(x)
biases = f - g_avg_x
expe_bias_g_sq = mean(biases^2)
expe_bias_g_sq
```

```
## [1] 0.4414531
```

```
plot_obj = ggplot() +
  xlim(x_min, x_max) + ylim(x_min^2, x_max^2)

for (nsim in 1 : min(Nsim, 100)){ #otherwise takes too long
  plot_obj = plot_obj + geom_abline(intercept = training_gs[nsim, 1], slope = training_gs[nsim, 2], col
}

plot_obj +
  geom_abline(intercept = g_average[1], slope = g_average[2], col = "black", lwd = 2) +
  ylim(-3,3)
```

```
## Scale for 'y' is already present. Adding another scale for 'y', which will
## replace the existing scale.
```




```
  # geom_line(data = f_x_df, aes(x, f), col = "green", size = 1)

x = seq(x_min, x_max, length.out = resolution)
expe_g_x = g_average[1] + g_average[2] * x
var_x_s = array(NA, Nsim)
for (nsim in 1 : Nsim){
  g_x = training_gs[nsim, 1] + training_gs[nsim, 2] * x
  var_x_s[nsim] = mean((g_x - expe_g_x)^2)
}
expe_var_g = mean(var_x_s)
expe_var_g
```

```
## [1] 0.05249671
```

```
MSE
```

```
## [1] 0.5843797
```

```
sigma^2
```

```
## [1] 0.09
```

```r
expe_bias_g_sq
```

```
## [1] 0.4414531
```

```r
expe_var_g
```

```
## [1] 0.05249671
```

```r
sigma^2 + expe_bias_g_sq + expe_var_g
```

```
## [1] 0.5839498
```

```r
rm(list = ls())
```

Take a sample of n = 2000 observations from the diamonds data.

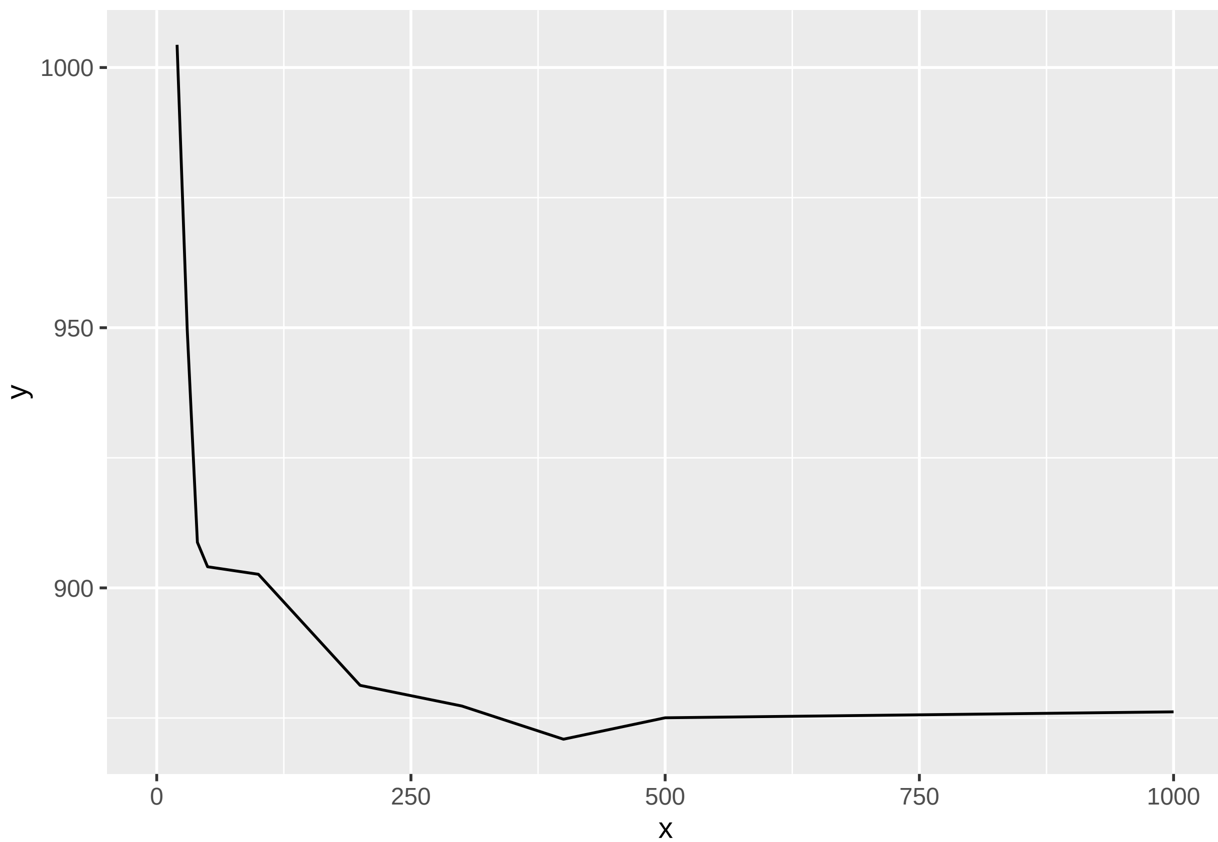
```r
pacman::p_load(dplyr)
diamond_samp = diamonds %>%
  sample_n(2000)
```

find the bootstrap s_e for a RF model using 1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000 trees. If you are using the `randomForest` package, you can calculate oob residuals via `e_oob = y_train - rf_mod$predicted`.

```r
num_trees = c(1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000)
oob_se_by_num_trees = array(NA, length(num_trees))
for(i in 1:length(num_trees)){
  rf_mod = randomForest(price ~., data = diamond_samp, ntree = num_trees[i])
  oob_se_by_num_trees[i] = sd(diamond_samp$price - rf_mod$predicted)
}

ggplot(data.frame(x = num_trees, y = oob_se_by_num_trees)) +
  geom_line(aes(x = x, y = y))
```

```
## Warning: Removed 4 row(s) containing missing values (geom_path).
```



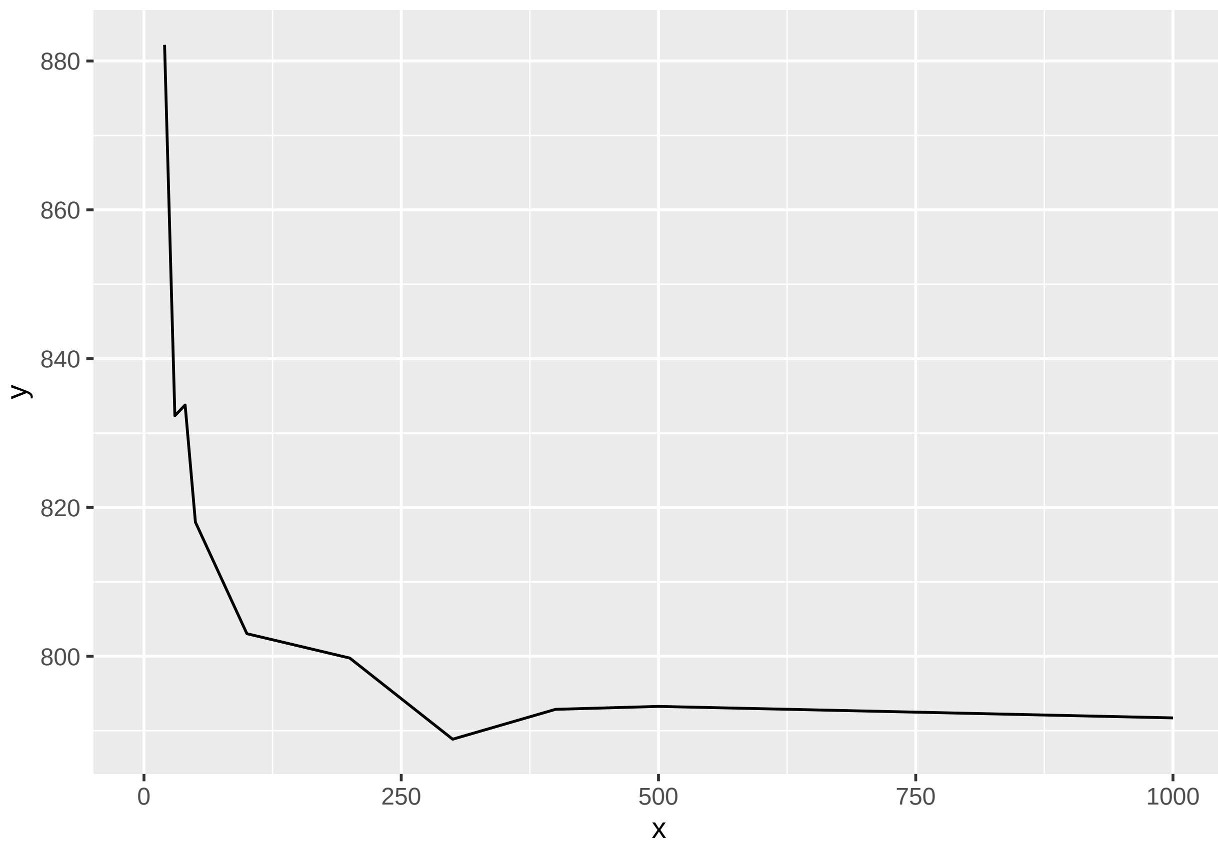
Using the diamonds data, find the bootstrap oob s_e for a bagged-tree model using 1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000 trees. If you are using the `randomForest` package, you can create the bagged tree model via setting an argument within the RF constructor function.

```
num_trees = c(1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000)
oob_se_by_num_trees_bag = array(NA, length(num_trees))

for(i in 1:length(num_trees)){
  rf_mod = randomForest(price ~., data = diamond_samp, ntree = num_trees[i], mtry = ncol(diamond_samp) -
  oob_se_by_num_trees_bag[i] = sd(diamond_samp$price - rf_mod$predicted)
}

ggplot(data.frame(x = num_trees, y = oob_se_by_num_trees_bag)) +
  geom_line(aes(x = x, y = y))
```

```
## Warning: Removed 4 row(s) containing missing values (geom_path).
```



What is the percentage gain / loss in performance of the RF model vs bagged trees model?

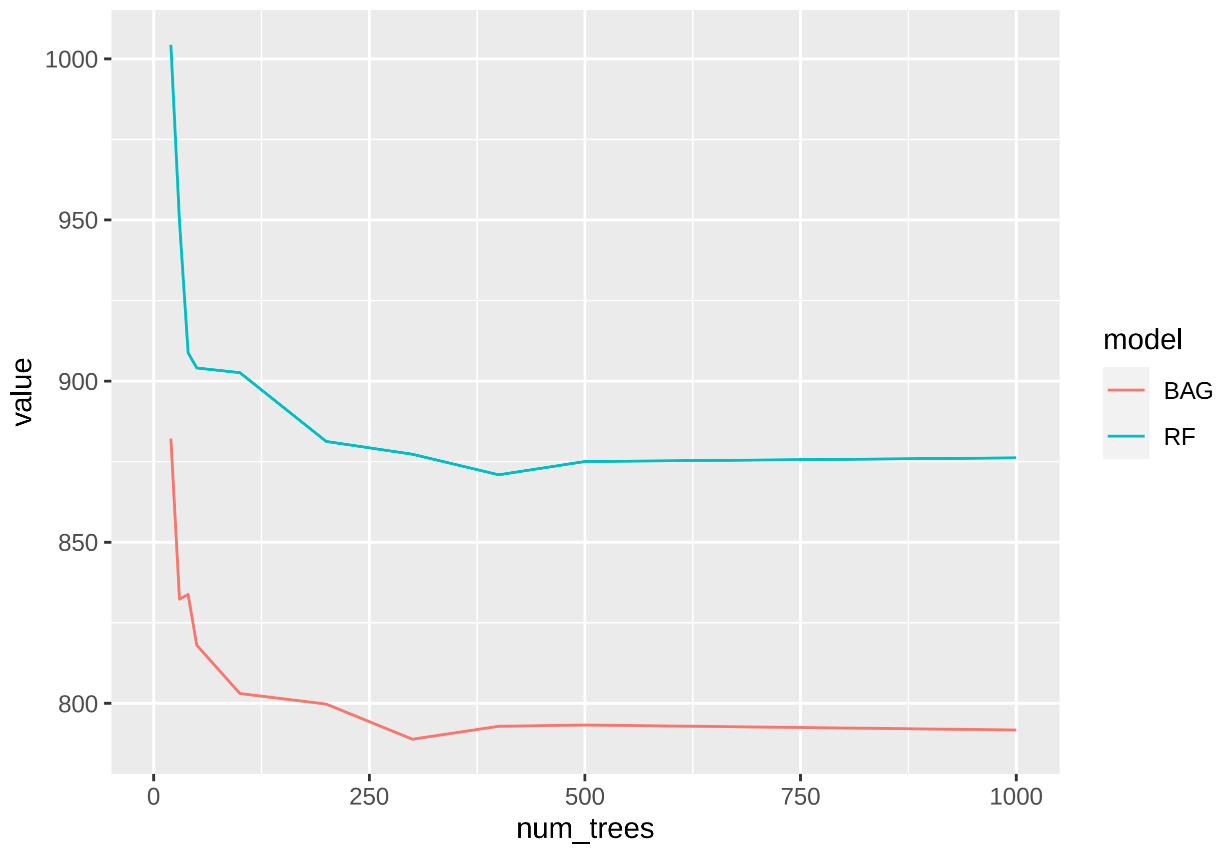
```
(oob_se_by_num_trees - oob_se_by_num_trees_bag) / oob_se_by_num_trees_bag * 100
```

```
##  [1]        NA        NA        NA        NA 13.850269 14.085703  8.994056
##  [8] 10.517395 12.400595 10.192240 11.212516  9.844600 10.309096 10.668566
```

Plot bootstrap s_e by number of trees for both RF and bagged trees.

```
ggplot(rbind(data.frame(num_trees = num_trees, value = oob_se_by_num_trees, model = "RF"), data.frame(nu
  geom_line(aes(x = num_trees, y = value, color = model))
```

```
## Warning: Removed 8 row(s) containing missing values (geom_path).
```

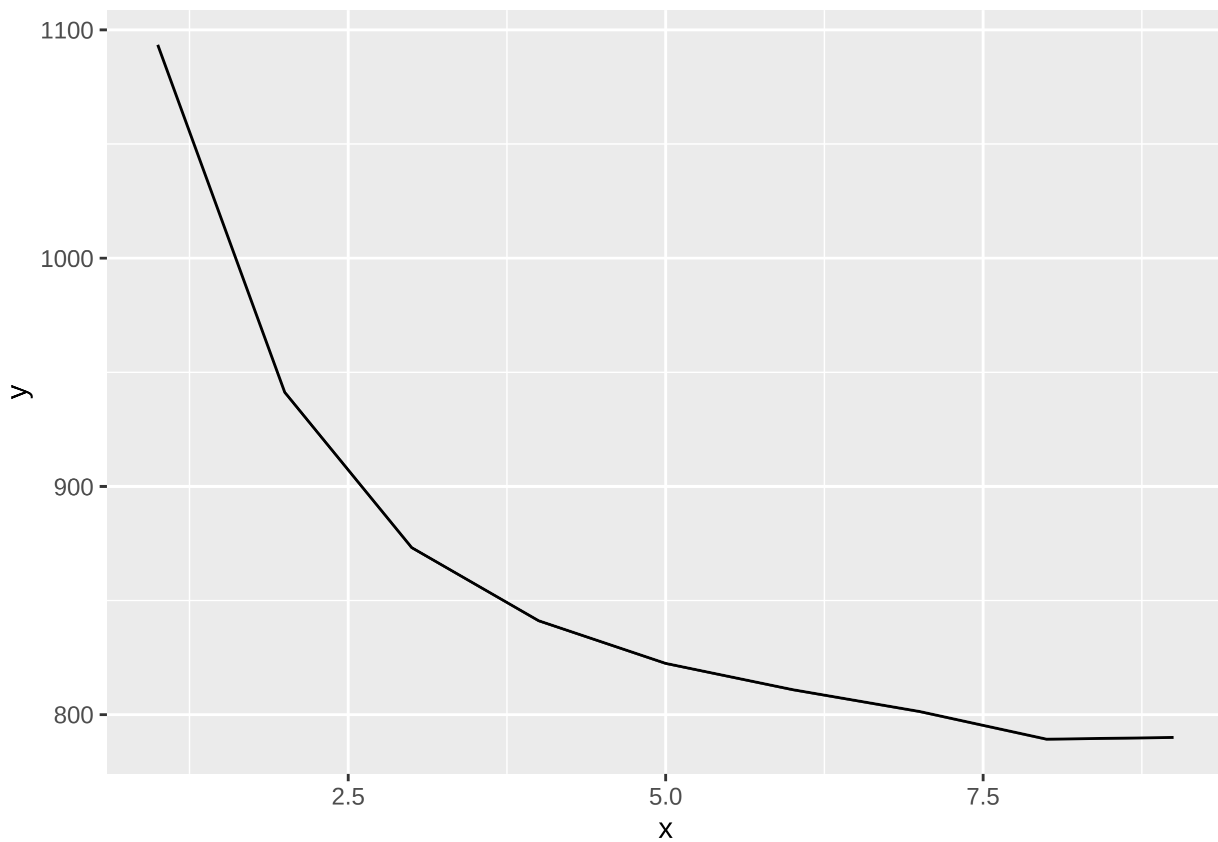


Build RF models for 500 trees using different `mtry` values: 1, 2, ... the maximum. That maximum will be the number of features assuming that we do not binarize categorical features if you are using `randomForest` or the number of features assuming binarization of the categorical features if you are using `YARF`. Calculate bootstrap s_e for all mtry values.

```
mtrys = 1:(ncol(diamond_samp) - 1)
oob_se_by_mtrys = array(NA, length(mtrys))

for(i in 1:length(mtrys)){
  rf_mod = randomForest(price ~., data = diamond_samp, mtry = mtrys[i])
  oob_se_by_mtrys[i] = sd(diamond_samp$price - rf_mod$predicted)
}

ggplot(data.frame(x = mtrys, y = oob_se_by_mtrys)) +
  geom_line(aes(x = x, y = y))
```




```
rm(list = ls())
```

Take a sample of n = 2000 observations from the adult data.

```
pacman::p_load_gh("coatless/ucidata")
data(adult)
adult = na.omit(adult) #kill any observations with missingness
adult_samp = adult %>%
sample_n(2000)
```

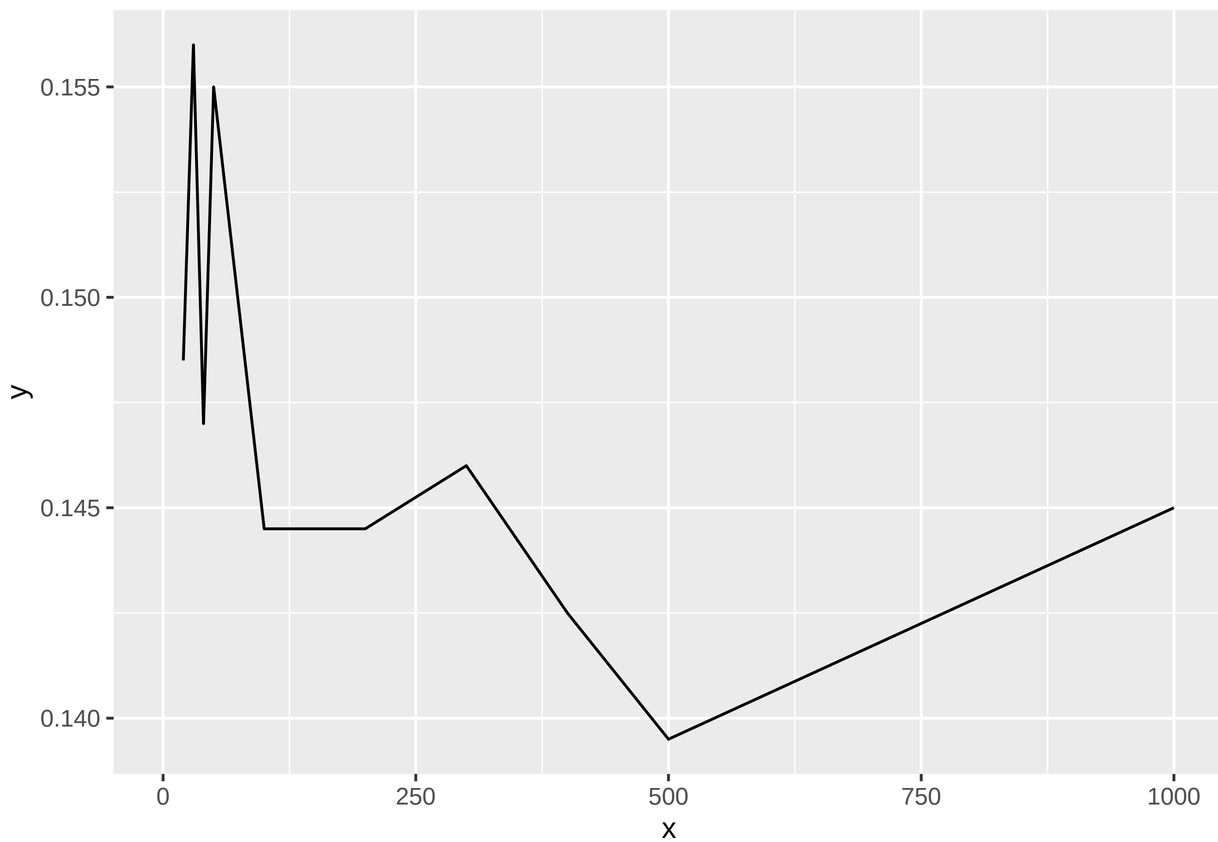
Using the adult data, find the bootstrap misclassification error for an RF model using 1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000 trees.

```
num_trees = c(1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000)
oob_me_by_num_trees = array(NA, length(num_trees))

for(i in 1:length(num_trees)){
  rf_mod = randomForest(income ~., data = adult_samp, ntree = num_trees[i])
  oob_me_by_num_trees[i] = mean(adult_samp$income !=  rf_mod$predicted)
}

ggplot(data.frame(x = num_trees, y = oob_me_by_num_trees)) +
  geom_line(aes(x = x, y = y))
```

```
## Warning: Removed 4 row(s) containing missing values (geom_path).
```



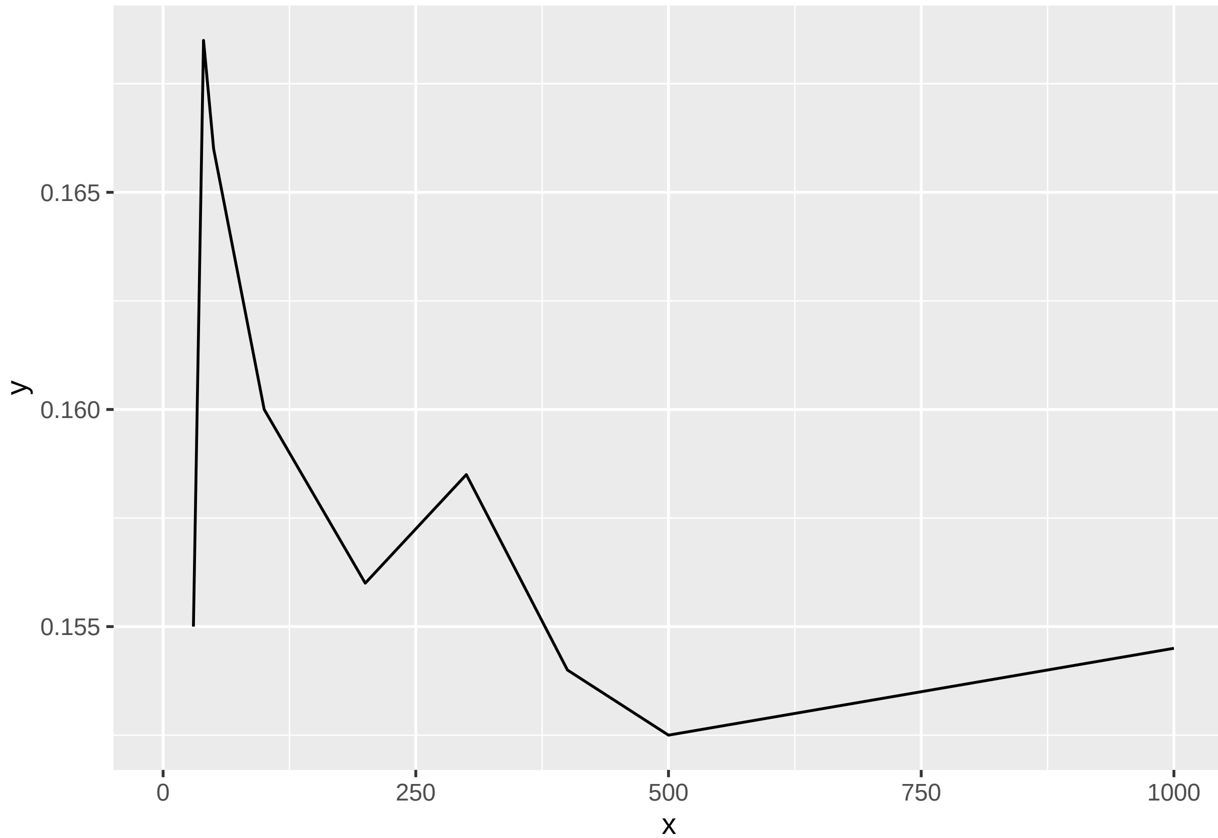
Using the adult data, find the bootstrap misclassification error for a bagged-tree model using 1, 2, 5, 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000 trees.

```
oob_me_by_num_trees_bag = array(NA, length(num_trees))

for(i in 1:length(num_trees)){
  rf_mod = randomForest(income ~., data = adult_samp, ntree = num_trees[i], mtry = ncol(adult) - 1)
  oob_me_by_num_trees_bag[i] = mean(adult_samp$income !=  rf_mod$predicted)
}

ggplot(data.frame(x = num_trees, y = oob_me_by_num_trees_bag)) +
  geom_line(aes(x = x, y = y))
```

```
## Warning: Removed 5 row(s) containing missing values (geom_path).
```



What is the percentage gain / loss in performance of the RF model vs bagged trees model?

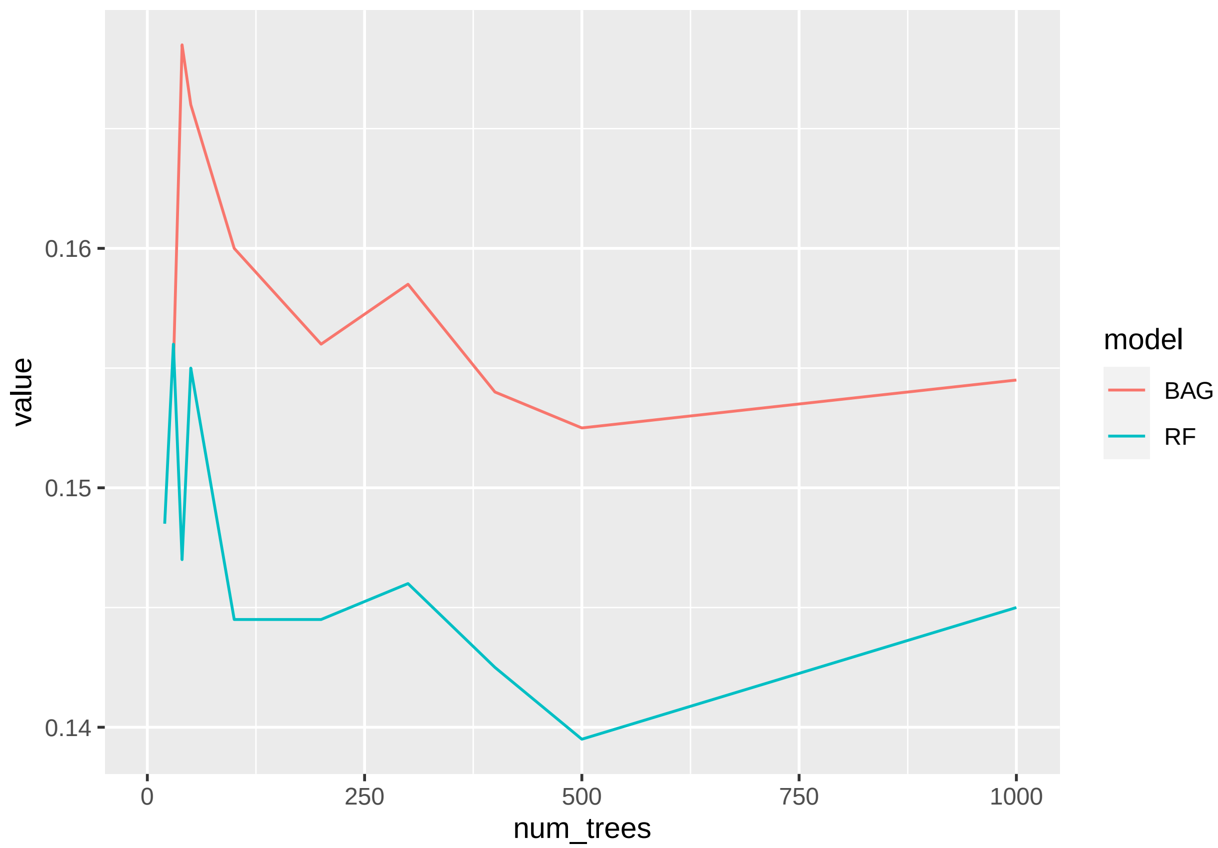
```
(oob_me_by_num_trees - oob_me_by_num_trees_bag)/ (oob_me_by_num_trees_bag * 100)
```

```
##  [1]            NA            NA            NA            NA            NA
##  [6]  6.451613e-05 -1.275964e-03 -6.626506e-04 -9.687500e-04 -7.371795e-04
## [11] -7.886435e-04 -7.467532e-04 -8.524590e-04 -6.148867e-04
```

Plot bootstrap misclassification error by number of trees for both RF and bagged trees.

```
ggplot(rbind(data.frame(num_trees = num_trees, value = oob_me_by_num_trees, model = "RF"), data.frame(nu
  geom_line(aes(x = num_trees, y = value, color = model))
```

```
## Warning: Removed 9 row(s) containing missing values (geom_path).
```

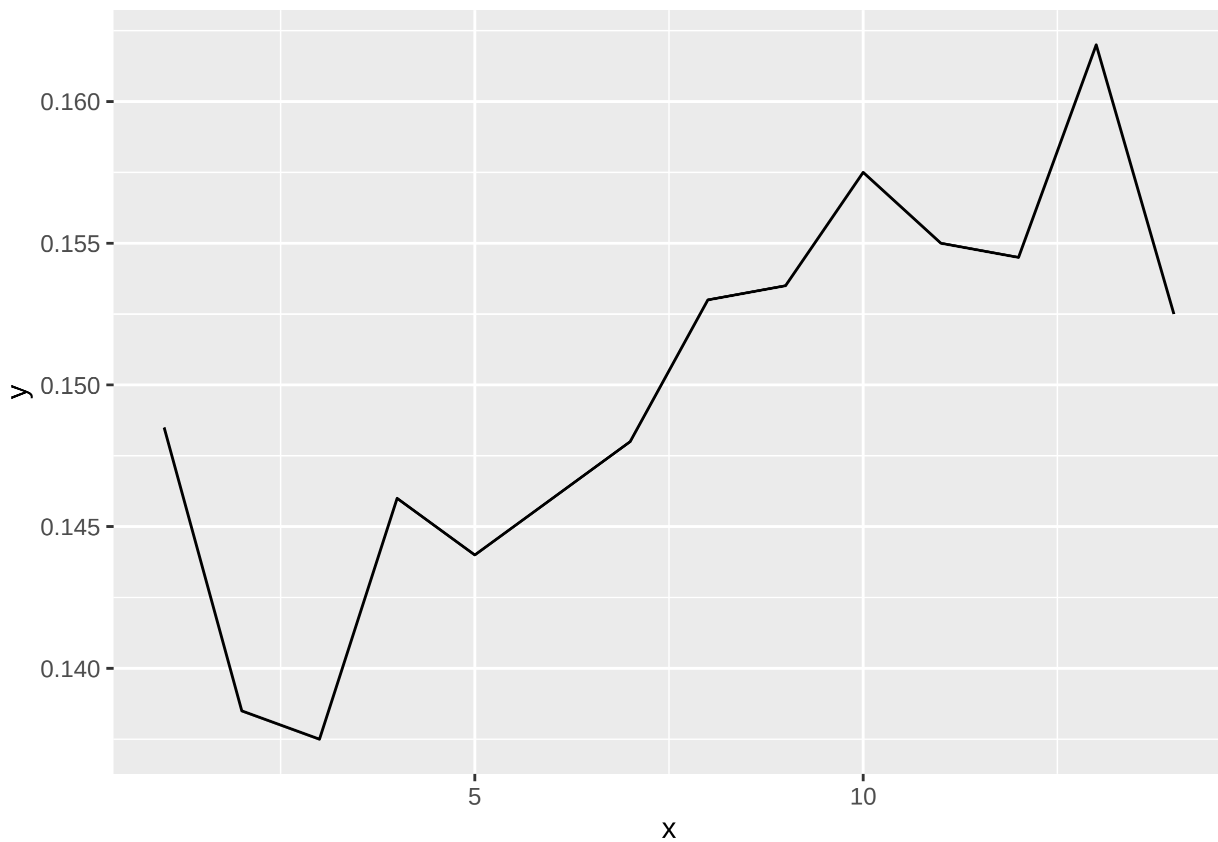


Build RF models for 500 trees using different `mtry` values: 1, 2, … the maximum (see above as maximum is defined by the specific RF algorithm implementation).

```
mtrys = 1:(ncol(adult_samp) - 1)
oob_me_by_mtrys = array(NA, length(mtrys))

for(i in 1:length(mtrys)){
  rf_mod = randomForest(income ~., data = adult_samp, mtry = mtrys[i])
  oob_me_by_mtrys[i] = mean(adult_samp$income !=  rf_mod$predicted)
}

ggplot(data.frame(x = mtrys, y = oob_me_by_mtrys)) +
  geom_line(aes(x = x, y = y))
```




```
rm(list = ls())
```

Write a function `random_bagged_ols` which takes as its arguments `X` and `y` with further arguments `num_ols_models` defaulted to 100 and `mtry` defaulted to NULL which then gets set within the function to be 50% of available features. This argument builds an OLS on a bootstrap sample of the data and uses only `mtry < p` of the available features. The function then returns all the `lm` models as a list with size `num_ols_models`.

```
random_bagged_ols = function(X, y, num_ols_model = 100, mtry = NULL){
  lm_models = array(NA, num_ols_model)

  for(i in 1:num_ols_model){
    columnsNum = round(runif(1, min = 1, max = ncol(X)))

    X_training = X[, sample(ncol(X), columnsNum)]

    n_not = round(runif(1, min = 1, max = nrow(X)))
    n = round(runif(1, min = 1, max = nrow(X)))

    matrix_X = X_training[0:n_not]

    for(i in 1:n_not){
      matrix_X[i,] = X_training[n[i],]
    }
```

```
    vector_y = array(NA, n_not)

    for(i in 1:n_not){
      vector_y[i] = y[n[i]]
    }

    models = lm(vector ~. + 0, data.frame(matrix_X))
    lm_models[i] =c(models$coefficients)
  }
  lm_models
}
```

Load up the Boston Housing Data and separate into `X` and `y`.

```
#From lab 10
pacman::p_load(MASS)
y = Boston$medv
X = Boston[, 1:13]
```

Similar to lab 1, write a function that takes a matrix and punches holes (i.e. sets entries equal to `NA`) randomly with an argument `prob_missing`.

```
#From lab 10
punching_holes = function(X, prob_missing){
  for(i in 1:nrow(X)){
    for(j in 1:ncol(X)) {
      if(runif(1) < prob_missing) {
         X[i,j] = NA
        }
      }
    }
    X
 }
```

Create a matrix `Xmiss` which is `X` but has missingness with probability of 10%.

```
Xmiss = punching_holes(X, .10)
Xmiss
```

```
##         crim   zn indus chas    nox    rm   age    dis rad tax ptratio  black
## 1    0.00632 18.0  2.31    0 0.5380 6.575  65.2 4.0900  NA 296    15.3 396.90
## 2         NA  0.0  7.07    0     NA 6.421    NA 4.9671   2 242      NA     NA
## 3    0.02729  0.0  7.07    0     NA 7.185  61.1 4.9671   2 242    17.8 392.83
## 4    0.03237  0.0  2.18    0 0.4580    NA    NA 6.0622   3 222    18.7     NA
## 5    0.06905  0.0  2.18    0 0.4580 7.147  54.2 6.0622   3 222    18.7 396.90
## 6    0.02985  0.0  2.18    0 0.4580 6.430  58.7 6.0622  NA 222    18.7 394.12
## 7    0.08829 12.5  7.87    0 0.5240 6.012  66.6 5.5605   5 311    15.2 395.60
## 8    0.14455 12.5  7.87   NA 0.5240 6.172  96.1 5.9505  NA 311    15.2 396.90
## 9    0.21124 12.5  7.87   NA 0.5240 5.631 100.0 6.0821   5 311    15.2 386.63
## 10   0.17004 12.5  7.87    0 0.5240 6.004  85.9 6.5921   5 311    15.2 386.71
## 11   0.22489 12.5  7.87    0 0.5240 6.377  94.3 6.3467  NA 311    15.2 392.52
## 12        NA 12.5  7.87    0 0.5240 6.009  82.9 6.2267   5 311    15.2 396.90
```

```
## 13   0.09378  12.5  7.87    0 0.5240 5.889  39.0      NA   5 311    15.2 390.50
## 14        NA   0.0  8.14    0 0.5380 5.949  61.8  4.7075   4 307    21.0 396.90
## 15   0.63796   0.0  8.14    0     NA 6.096  84.5  4.4619  NA 307    21.0 380.02
## 16        NA   0.0  8.14    0     NA 5.834  56.5  4.4986  NA 307    21.0 395.62
## 17   1.05393   0.0    NA    0 0.5380 5.935  29.3  4.4986   4 307    21.0 386.85
## 18        NA   0.0    NA    0 0.5380    NA  81.7  4.2579   4 307    21.0 386.75
## 19   0.80271   0.0  8.14   NA 0.5380 5.456  36.6  3.7965   4 307    21.0 288.99
## 20        NA   0.0  8.14    0 0.5380 5.727  69.5  3.7965  NA  NA    21.0 390.95
## 21   1.25179    NA  8.14    0 0.5380 5.570  98.1  3.7979   4 307    21.0 376.57
## 22   0.85204   0.0  8.14    0 0.5380 5.965  89.2  4.0123   4 307    21.0 392.53
## 23   1.23247   0.0  8.14    0 0.5380 6.142  91.7  3.9769   4 307    21.0 396.90
## 24   0.98843   0.0  8.14    0 0.5380 5.813 100.0      NA  NA  NA    21.0 394.54
## 25   0.75026   0.0  8.14    0 0.5380    NA    NA  4.3996   4 307    21.0 394.33
## 26   0.84054   0.0  8.14   NA     NA 5.599  85.7  4.4546   4 307    21.0     NA
## 27        NA    NA  8.14    0 0.5380 5.813  90.3  4.6820   4 307    21.0     NA
## 28   0.95577   0.0  8.14    0 0.5380 6.047  88.8  4.4534   4 307    21.0 306.38
## 29   0.77299    NA    NA    0 0.5380 6.495  94.4  4.4547  NA 307    21.0 387.94
## 30   1.00245   0.0  8.14    0 0.5380 6.674  87.3  4.2390  NA 307    21.0 380.23
## 31   1.13081   0.0  8.14    0 0.5380 5.713  94.1  4.2330   4 307      NA 360.17
## 32   1.35472   0.0  8.14   NA 0.5380 6.072 100.0  4.1750   4 307    21.0 376.73
## 33   1.38799    NA  8.14    0 0.5380 5.950  82.0  3.9900   4  NA    21.0 232.60
## 34   1.15172   0.0  8.14    0 0.5380 5.701  95.0  3.7872   4 307    21.0 358.77
## 35   1.61282   0.0    NA    0 0.5380 6.096  96.9  3.7598   4 307    21.0 248.31
## 36   0.06417   0.0  5.96    0 0.4990 5.933  68.2  3.3603   5 279      NA 396.90
## 37   0.09744   0.0    NA    0 0.4990 5.841  61.4  3.3779   5 279    19.2     NA
## 38   0.08014   0.0  5.96    0 0.4990 5.850  41.5  3.9342   5 279    19.2 396.90
## 39   0.17505   0.0  5.96    0 0.4990 5.966  30.2  3.8473   5 279      NA 393.43
## 40   0.02763    NA  2.95    0     NA    NA  21.8      NA   3 252    18.3 395.63
## 41   0.03359  75.0  2.95    0 0.4280 7.024  15.8  5.4011   3 252    18.3 395.62
## 42        NA   0.0  6.91    0 0.4480 6.770   2.9  5.7209   3  NA    17.9 385.41
## 43   0.14150   0.0  6.91    0 0.4480 6.169   6.6  5.7209   3 233    17.9 383.37
## 44   0.15936   0.0  6.91    0 0.4480 6.211   6.5  5.7209   3 233    17.9 394.46
## 45   0.12269   0.0  6.91    0 0.4480 6.069  40.0  5.7209  NA 233    17.9 389.39
## 46   0.17142   0.0  6.91    0 0.4480 5.682  33.8      NA   3 233    17.9 396.90
## 47        NA   0.0  6.91    0 0.4480 5.786  33.3  5.1004   3 233    17.9 396.90
## 48   0.22927   0.0  6.91    0 0.4480 6.030  85.5      NA   3 233      NA 392.74
## 49        NA   0.0  6.91    0 0.4480 5.399    NA  5.8700   3 233    17.9 396.90
## 50   0.21977   0.0    NA    0 0.4480 5.602  62.0  6.0877   3  NA    17.9 396.90
## 51   0.08873  21.0  5.64    0 0.4390 5.963  45.7  6.8147   4 243      NA 395.56
## 52   0.04337    NA  5.64   NA     NA 6.115  63.0  6.8147  NA  NA    16.8 393.97
## 53   0.05360  21.0  5.64    0 0.4390 6.511  21.1  6.8147   4 243      NA 396.90
## 54   0.04981  21.0    NA    0     NA 5.998  21.4  6.8147   4 243    16.8 396.90
## 55   0.01360  75.0  4.00    0     NA 5.888  47.6  7.3197   3 469      NA 396.90
## 56   0.01311  90.0  1.22    0 0.4030 7.249  21.9  8.6966   5 226    17.9     NA
## 57   0.02055  85.0  0.74    0     NA 6.383  35.7  9.1876   2 313    17.3     NA
## 58        NA 100.0  1.32    0     NA 6.816  40.5  8.3248   5 256    15.1 392.90
## 59   0.15445  25.0  5.13    0 0.4530 6.145  29.2      NA   8 284      NA 390.68
## 60   0.10328  25.0  5.13    0     NA 5.927  47.2  6.9320   8 284    19.7 396.90
## 61   0.14932  25.0    NA    0     NA 5.741  66.2  7.2254   8 284    19.7 395.11
## 62   0.17171  25.0  5.13    0 0.4530 5.966  93.4  6.8185   8 284    19.7 378.08
## 63   0.11027    NA  5.13    0 0.4530 6.456  67.8  7.2255   8 284    19.7 396.90
## 64   0.12650  25.0  5.13    0 0.4530 6.762  43.4  7.9809   8 284      NA     NA
## 65   0.01951  17.5  1.38   NA 0.4161 7.104  59.5  9.2229   3 216    18.6 393.24
## 66   0.03584  80.0    NA    0 0.3980    NA    NA  6.6115   4 337    16.1 396.90
```

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## 67   0.04379  80.0  3.37    0 0.3980 5.787  31.1  6.6115   4 337    16.1 396.90
## 68   0.05789  12.5  6.07    0 0.4090 5.878    NA  6.4980   4 345    18.9 396.21
## 69   0.13554  12.5  6.07    0 0.4090 5.594  36.8  6.4980  NA 345    18.9 396.90
## 70   0.12816  12.5  6.07    0     NA 5.885    NA  6.4980   4 345    18.9     NA
## 71   0.08826   0.0 10.81    0 0.4130 6.417    NA  5.2873   4 305    19.2 383.73
## 72   0.15876   0.0 10.81    0 0.4130    NA  17.5  5.2873   4 305    19.2 376.94
## 73   0.09164   0.0 10.81    0     NA 6.065   7.8      NA   4 305    19.2 390.91
## 74   0.19539   0.0 10.81    0 0.4130 6.245   6.2  5.2873   4 305    19.2 377.17
## 75   0.07896   0.0 12.83    0 0.4370 6.273   6.0  4.2515   5 398    18.7 394.92
## 76   0.09512   0.0 12.83    0 0.4370 6.286  45.0  4.5026   5 398    18.7 383.23
## 77        NA   0.0 12.83    0     NA 6.279  74.5  4.0522   5 398    18.7 373.66
## 78   0.08707   0.0 12.83    0 0.4370 6.140  45.8  4.0905   5 398    18.7 386.96
## 79   0.05646   0.0    NA    0     NA 6.232  53.7  5.0141   5 398    18.7 386.40
## 80   0.08387   0.0 12.83    0 0.4370 5.874  36.6  4.5026   5 398    18.7     NA
## 81        NA  25.0  4.86    0 0.4260 6.727    NA  5.4007  NA 281      NA 396.90
## 82   0.04462  25.0    NA    0 0.4260 6.619  70.4      NA  NA 281    19.0 395.63
## 83   0.03659  25.0  4.86    0 0.4260 6.302  32.2  5.4007   4 281    19.0 396.90
## 84   0.03551  25.0  4.86    0 0.4260 6.167  46.7  5.4007   4 281    19.0 390.64
## 85   0.05059   0.0  4.49    0 0.4490 6.389  48.0  4.7794   3 247      NA 396.90
## 86   0.05735   0.0  4.49    0 0.4490 6.630  56.1  4.4377   3 247    18.5 392.30
## 87   0.05188    NA  4.49    0 0.4490 6.015  45.1      NA   3  NA    18.5     NA
## 88   0.07151   0.0  4.49    0 0.4490 6.121  56.8  3.7476   3 247    18.5 395.15
## 89   0.05660   0.0  3.41    0 0.4890 7.007  86.3  3.4217   2 270    17.8 396.90
## 90   0.05302   0.0  3.41    0 0.4890 7.079  63.1  3.4145   2 270    17.8 396.06
## 91   0.04684   0.0  3.41    0 0.4890 6.417  66.1  3.0923   2  NA    17.8 392.18
## 92   0.03932   0.0    NA    0     NA 6.405  73.9  3.0921   2 270    17.8 393.55
## 93   0.04203  28.0 15.04    0 0.4640 6.442  53.6  3.6659   4 270    18.2 395.01
## 94   0.02875  28.0 15.04    0 0.4640    NA    NA  3.6659  NA 270      NA 396.33
## 95   0.04294    NA 15.04    0 0.4640    NA  77.3  3.6150   4 270    18.2 396.90
## 96   0.12204   0.0  2.89    0 0.4450 6.625  57.8  3.4952  NA 276    18.0     NA
## 97   0.11504   0.0  2.89    0 0.4450 6.163  69.6  3.4952   2 276    18.0 391.83
## 98   0.12083   0.0    NA    0 0.4450 8.069  76.0      NA   2 276    18.0 396.90
## 99   0.08187   0.0  2.89    0     NA 7.820  36.9  3.4952   2 276    18.0 393.53
## 100  0.06860   0.0  2.89    0     NA 7.416  62.5  3.4952   2 276    18.0 396.90
## 101       NA   0.0  8.56    0 0.5200    NA  79.9      NA   5 384    20.9 394.76
## 102  0.11432   0.0  8.56    0 0.5200 6.781    NA  2.8561   5 384      NA 395.58
## 103  0.22876   0.0  8.56    0 0.5200 6.405  85.4  2.7147   5 384    20.9  70.80
## 104  0.21161   0.0  8.56    0 0.5200    NA  87.4  2.7147   5 384    20.9 394.47
## 105  0.13960   0.0  8.56    0 0.5200 6.167  90.0  2.4210   5  NA    20.9 392.69
## 106  0.13262    NA  8.56    0 0.5200 5.851  96.7  2.1069   5 384    20.9 394.05
## 107  0.17120   0.0  8.56    0 0.5200 5.836  91.9  2.2110   5 384    20.9 395.67
## 108  0.13117   0.0  8.56    0 0.5200 6.127  85.2  2.1224   5 384    20.9 387.69
## 109  0.12802   0.0  8.56    0 0.5200 6.474  97.1  2.4329   5  NA    20.9 395.24
## 110  0.26363   0.0  8.56    0 0.5200 6.229  91.2  2.5451   5 384    20.9 391.23
## 111  0.10793    NA  8.56    0     NA 6.195  54.4  2.7778   5 384    20.9 393.49
## 112  0.10084   0.0 10.01    0 0.5470 6.715  81.6  2.6775   6 432    17.8 395.59
## 113  0.12329   0.0 10.01    0     NA 5.913  92.9      NA   6 432    17.8 394.95
## 114  0.22212   0.0 10.01   NA 0.5470 6.092  95.4      NA   6  NA    17.8 396.90
## 115  0.14231   0.0    NA    0 0.5470 6.254  84.2  2.2565   6 432      NA 388.74
## 116  0.17134   0.0 10.01    0 0.5470 5.928  88.2      NA  NA 432    17.8 344.91
## 117  0.13158   0.0 10.01    0 0.5470 6.176  72.5  2.7301   6 432    17.8 393.30
## 118  0.15098   0.0 10.01    0 0.5470 6.021  82.6  2.7474   6 432    17.8 394.51
## 119  0.13058   0.0 10.01    0     NA 5.872  73.1  2.4775   6 432    17.8 338.63
## 120       NA   0.0 10.01    0 0.5470 5.731  65.2  2.7592   6 432    17.8 391.50
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## 121  0.06899   0.0 25.65    0 0.5810 5.870  69.7  2.2577   2 188    19.1 389.15
## 122  0.07165   0.0 25.65    0 0.5810 6.004  84.1  2.1974   2 188      NA 377.67
## 123  0.09299   0.0 25.65    0 0.5810 5.961  92.9  2.0869   2 188    19.1 378.09
## 124       NA   0.0 25.65    0 0.5810 5.856  97.0  1.9444   2 188      NA 370.31
## 125  0.09849   0.0 25.65    0 0.5810 5.879  95.8  2.0063   2 188    19.1 379.38
## 126  0.16902   0.0 25.65    0 0.5810    NA  88.4  1.9929   2 188    19.1 385.02
## 127  0.38735   0.0 25.65    0 0.5810 5.613  95.6      NA   2 188    19.1 359.29
## 128  0.25915   0.0 21.89    0 0.6240 5.693  96.0  1.7883   4 437    21.2 392.11
## 129  0.32543   0.0 21.89    0 0.6240 6.431  98.8  1.8125   4 437    21.2 396.90
## 130  0.88125   0.0 21.89    0 0.6240 5.637  94.7  1.9799  NA 437    21.2 396.90
## 131  0.34006    NA 21.89    0 0.6240    NA  98.9  2.1185   4 437    21.2 395.04
## 132  1.19294    NA 21.89    0 0.6240    NA  97.7  2.2710   4 437    21.2 396.90
## 133  0.59005   0.0 21.89    0 0.6240 6.372  97.9  2.3274   4 437    21.2 385.76
## 134  0.32982    NA 21.89    0     NA 5.822  95.4  2.4699   4 437    21.2 388.69
## 135  0.97617   0.0 21.89    0 0.6240 5.757  98.4  2.3460   4 437    21.2 262.76
## 136  0.55778   0.0 21.89   NA 0.6240 6.335  98.2  2.1107   4 437    21.2 394.67
## 137  0.32264   0.0 21.89    0 0.6240 5.942  93.5  1.9669   4 437    21.2 378.25
## 138  0.35233   0.0 21.89    0 0.6240 6.454    NA  1.8498   4 437    21.2 394.08
## 139  0.24980   0.0 21.89    0 0.6240 5.857  98.2  1.6686   4 437    21.2 392.04
## 140  0.54452   0.0 21.89    0 0.6240 6.151  97.9  1.6687   4 437    21.2 396.90
## 141       NA   0.0 21.89    0 0.6240 6.174    NA      NA   4 437      NA 388.08
## 142  1.62864   0.0 21.89    0 0.6240 5.019 100.0  1.4394   4 437      NA 396.90
## 143  3.32105   0.0 19.58    1 0.8710 5.403 100.0  1.3216  NA 403    14.7 396.90
## 144  4.09740   0.0    NA    0 0.8710 5.468 100.0  1.4118   5  NA    14.7 396.90
## 145  2.77974   0.0 19.58    0 0.8710 4.903  97.8  1.3459   5 403    14.7 396.90
## 146  2.37934    NA 19.58    0 0.8710 6.130 100.0  1.4191   5 403    14.7 172.91
## 147  2.15505   0.0 19.58    0 0.8710 5.628 100.0  1.5166   5 403    14.7 169.27
## 148  2.36862   0.0 19.58    0 0.8710 4.926  95.7  1.4608  NA 403    14.7 391.71
## 149  2.33099   0.0 19.58   NA 0.8710 5.186  93.8  1.5296   5  NA    14.7 356.99
## 150  2.73397   0.0 19.58    0 0.8710 5.597  94.9  1.5257   5 403    14.7 351.85
## 151  1.65660   0.0 19.58    0 0.8710 6.122    NA  1.6180   5 403    14.7 372.80
## 152  1.49632   0.0 19.58    0 0.8710 5.404    NA      NA   5 403    14.7 341.60
## 153  1.12658   0.0 19.58    1 0.8710 5.012  88.0  1.6102   5 403    14.7 343.28
## 154       NA   0.0 19.58   NA 0.8710 5.709  98.5  1.6232   5 403    14.7 261.95
## 155  1.41385   0.0 19.58    1 0.8710 6.129  96.0  1.7494   5 403    14.7 321.02
## 156  3.53501   0.0 19.58    1 0.8710 6.152  82.6  1.7455  NA 403    14.7  88.01
## 157  2.44668   0.0 19.58   NA     NA 5.272  94.0  1.7364   5 403    14.7  88.63
## 158  1.22358   0.0 19.58    0 0.6050 6.943  97.4  1.8773   5 403    14.7 363.43
## 159       NA   0.0 19.58   NA 0.6050    NA 100.0  1.7573   5 403    14.7 353.89
## 160  1.42502   0.0 19.58    0 0.8710 6.510 100.0  1.7659   5 403    14.7 364.31
## 161  1.27346   0.0 19.58    1 0.6050 6.250  92.6  1.7984   5  NA      NA 338.92
## 162  1.46336   0.0    NA   NA 0.6050    NA  90.8  1.9709   5 403    14.7 374.43
## 163  1.83377   0.0 19.58    1 0.6050 7.802  98.2  2.0407   5 403    14.7 389.61
## 164  1.51902   0.0 19.58    1 0.6050 8.375  93.9  2.1620   5  NA    14.7 388.45
## 165  2.24236   0.0 19.58    0 0.6050 5.854  91.8  2.4220   5 403    14.7 395.11
## 166  2.92400   0.0 19.58    0 0.6050 6.101  93.0  2.2834   5 403    14.7 240.16
## 167  2.01019   0.0 19.58   NA 0.6050 7.929  96.2      NA   5 403    14.7 369.30
## 168  1.80028   0.0 19.58    0 0.6050 5.877  79.2  2.4259   5 403    14.7 227.61
## 169  2.30040   0.0    NA    0 0.6050 6.319  96.1  2.1000   5 403    14.7 297.09
## 170  2.44953   0.0 19.58    0 0.6050    NA  95.2  2.2625   5 403    14.7 330.04
## 171  1.20742   0.0 19.58    0     NA 5.875  94.6  2.4259  NA 403    14.7 292.29
## 172  2.31390    NA 19.58    0 0.6050 5.880  97.3  2.3887   5 403    14.7 348.13
## 173  0.13914   0.0  4.05    0 0.5100 5.572  88.5  2.5961   5 296    16.6 396.90
## 174  0.09178    NA  4.05    0 0.5100 6.416  84.1  2.6463   5 296    16.6 395.50
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## 175  0.08447  0.0  4.05    0 0.5100    NA  68.7  2.7019   5 296    16.6 393.23
## 176  0.06664  0.0  4.05   NA 0.5100 6.546  33.1  3.1323   5 296    16.6     NA
## 177  0.07022  0.0  4.05    0 0.5100 6.020    NA  3.5549  NA 296    16.6 393.23
## 178  0.05425  0.0    NA    0 0.5100    NA    NA  3.3175   5 296    16.6 395.60
## 179  0.06642  0.0  4.05    0 0.5100 6.860  74.4  2.9153  NA 296    16.6 391.27
## 180  0.05780  0.0  2.46    0 0.4880 6.980  58.4      NA   3 193    17.8 396.90
## 181  0.06588  0.0  2.46    0 0.4880 7.765  83.3  2.7410   3 193    17.8 395.56
## 182  0.06888  0.0  2.46    0 0.4880 6.144  62.2      NA   3  NA    17.8 396.90
## 183  0.09103  0.0  2.46    0 0.4880 7.155  92.2      NA   3 193    17.8 394.12
## 184  0.10008  0.0  2.46    0 0.4880 6.563  95.6  2.8470   3  NA    17.8 396.90
## 185  0.08308  0.0  2.46    0 0.4880 5.604  89.8  2.9879  NA 193    17.8 391.00
## 186  0.06047  0.0  2.46   NA 0.4880 6.153  68.8  3.2797   3 193    17.8 387.11
## 187  0.05602  0.0  2.46    0 0.4880 7.831  53.6      NA   3  NA    17.8 392.63
## 188  0.07875 45.0  3.44    0 0.4370 6.782    NA  3.7886  NA 398    15.2 393.87
## 189       NA 45.0  3.44    0 0.4370 6.556  29.1  4.5667  NA 398      NA 382.84
## 190  0.08370 45.0  3.44    0 0.4370 7.185  38.9  4.5667   5 398    15.2 396.90
## 191  0.09068 45.0    NA    0 0.4370 6.951  21.5  6.4798   5 398    15.2 377.68
## 192  0.06911 45.0  3.44    0 0.4370 6.739  30.8  6.4798   5 398    15.2 389.71
## 193       NA   NA  3.44   NA 0.4370 7.178    NA  6.4798   5 398    15.2 390.49
## 194  0.02187 60.0  2.93    0 0.4010 6.800   9.9  6.2196   1  NA    15.6     NA
## 195  0.01439 60.0  2.93    0 0.4010 6.604  18.8  6.2196   1 265    15.6 376.70
## 196  0.01381 80.0  0.46    0 0.4220 7.875  32.0  5.6484   4 255    14.4 394.23
## 197  0.04011 80.0  1.52   NA 0.4040 7.287  34.1  7.3090   2 329    12.6 396.90
## 198  0.04666 80.0  1.52    0 0.4040 7.107  36.6  7.3090   2 329    12.6 354.31
## 199       NA 80.0  1.52    0 0.4040    NA  38.3  7.3090   2 329    12.6 392.20
## 200  0.03150 95.0  1.47    0 0.4030 6.975  15.3  7.6534   3 402    17.0 396.90
## 201  0.01778 95.0  1.47    0 0.4030 7.135  13.9  7.6534  NA 402    17.0 384.30
## 202  0.03445 82.5  2.03    0 0.4150 6.162  38.4  6.2700   2 348    14.7 393.77
## 203  0.02177   NA  2.03    0 0.4150 7.610  15.7      NA   2 348    14.7 395.38
## 204  0.03510 95.0  2.68    0 0.4161 7.853  33.2  5.1180   4 224      NA 392.78
## 205  0.02009 95.0  2.68    0 0.4161 8.034  31.9  5.1180   4 224    14.7 390.55
## 206  0.13642  0.0 10.59    0 0.4890 5.891  22.3  3.9454   4 277      NA 396.90
## 207  0.22969  0.0 10.59    0 0.4890    NA  52.5  4.3549   4 277    18.6 394.87
## 208  0.25199  0.0 10.59    0 0.4890 5.783  72.7  4.3549   4 277    18.6 389.43
## 209  0.13587  0.0 10.59    1 0.4890 6.064  59.1  4.2392   4 277    18.6 381.32
## 210  0.43571  0.0 10.59    1 0.4890 5.344 100.0  3.8750   4  NA    18.6 396.90
## 211  0.17446  0.0 10.59    1 0.4890    NA  92.1  3.8771   4 277    18.6 393.25
## 212  0.37578  0.0 10.59    1 0.4890 5.404  88.6      NA   4 277    18.6 395.24
## 213  0.21719  0.0 10.59   NA 0.4890 5.807    NA  3.6526   4  NA    18.6 390.94
## 214  0.14052  0.0 10.59    0 0.4890 6.375  32.3  3.9454   4 277    18.6 385.81
## 215  0.28955  0.0 10.59    0 0.4890 5.412   9.8  3.5875   4 277    18.6 348.93
## 216  0.19802  0.0 10.59    0 0.4890 6.182  42.4  3.9454   4 277    18.6 393.63
## 217  0.04560  0.0 13.89   NA 0.5500 5.888    NA  3.1121   5  NA    16.4     NA
## 218  0.07013  0.0 13.89    0 0.5500 6.642  85.1  3.4211   5 276      NA 392.78
## 219  0.11069  0.0 13.89    1 0.5500 5.951    NA      NA   5 276    16.4 396.90
## 220  0.11425  0.0    NA    1 0.5500    NA  92.4  3.3633  NA 276    16.4 393.74
## 221  0.35809  0.0  6.20    1 0.5070    NA  88.5  2.8617   8 307    17.4 391.70
## 222  0.40771  0.0  6.20    1 0.5070 6.164  91.3      NA   8 307    17.4 395.24
## 223  0.62356  0.0  6.20    1 0.5070 6.879  77.7  3.2721   8  NA    17.4 390.39
## 224  0.61470  0.0  6.20    0     NA 6.618  80.8  3.2721   8 307    17.4 396.90
## 225  0.31533  0.0  6.20    0 0.5040 8.266  78.3  2.8944   8 307    17.4 385.05
## 226  0.52693  0.0  6.20    0 0.5040 8.725  83.0  2.8944   8 307    17.4 382.00
## 227  0.38214  0.0  6.20    0 0.5040 8.040  86.5  3.2157  NA 307    17.4 387.38
## 228       NA  0.0  6.20    0 0.5040 7.163  79.9  3.2157   8  NA    17.4     NA
```

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## 229 0.29819  0.0   NA    0 0.5040 7.686  17.0 3.3751 NA 307    17.4 377.51
## 230 0.44178  0.0   NA    0 0.5040 6.552  21.4 3.3751  8 307    17.4 380.34
## 231 0.53700  0.0 6.20    0 0.5040 5.981  68.1 3.6715 NA 307    17.4 378.35
## 232 0.46296   NA 6.20    0 0.5040 7.412  76.9     NA  8 307    17.4 376.14
## 233 0.57529  0.0 6.20    0 0.5070 8.337  73.3 3.8384 NA 307    17.4 385.91
## 234 0.33147  0.0   NA    0 0.5070 8.247  70.4 3.6519  8 307      NA 378.95
## 235 0.44791  0.0   NA    1 0.5070    NA  66.5 3.6519  8 307    17.4 360.20
## 236 0.33045  0.0 6.20    0 0.5070 6.086  61.5 3.6519  8 307    17.4 376.75
## 237 0.52058  0.0 6.20    1 0.5070 6.631  76.5 4.1480  8 307    17.4 388.45
## 238 0.51183  0.0   NA    0 0.5070 7.358  71.6 4.1480  8 307    17.4 390.07
## 239 0.08244 30.0 4.93    0 0.4280 6.481  18.5 6.1899  6 300    16.6 379.41
## 240 0.09252 30.0 4.93    0 0.4280 6.606  42.2 6.1899  6 300    16.6 383.78
## 241 0.11329 30.0 4.93    0 0.4280 6.897  54.3 6.3361  6 300    16.6 391.25
## 242 0.10612   NA   NA    0 0.4280 6.095  65.1 6.3361  6  NA    16.6 394.62
## 243 0.10290 30.0 4.93    0 0.4280 6.358  52.9 7.0355  6 300    16.6 372.75
## 244 0.12757 30.0 4.93    0 0.4280 6.393   7.8 7.0355  6 300      NA 374.71
## 245 0.20608 22.0 5.86    0 0.4310 5.593  76.5 7.9549 NA 330    19.1     NA
## 246 0.19133 22.0 5.86    0 0.4310    NA  70.2 7.9549 NA 330    19.1 389.13
## 247 0.33983 22.0 5.86    0 0.4310 6.108  34.9 8.0555  7 330    19.1 390.18
## 248 0.19657 22.0 5.86    0 0.4310 6.226  79.2 8.0555  7 330    19.1 376.14
## 249 0.16439 22.0 5.86    0 0.4310 6.433  49.1 7.8265  7 330    19.1     NA
## 250 0.19073 22.0 5.86    0 0.4310 6.718    NA 7.8265  7 330    19.1 393.74
## 251 0.14030   NA 5.86    0 0.4310 6.487    NA 7.3967  7 330    19.1 396.28
## 252 0.21409 22.0   NA    0 0.4310 6.438   8.9 7.3967  7 330      NA     NA
## 253 0.08221 22.0   NA    0 0.4310 6.957   6.8 8.9067  7 330    19.1 386.09
## 254 0.36894 22.0   NA    0 0.4310 8.259   8.4 8.9067  7 330    19.1 396.90
## 255 0.04819 80.0 3.64    0 0.3920 6.108  32.0 9.2203  1 315    16.4 392.89
## 256 0.03548 80.0   NA    0 0.3920 5.876  19.1 9.2203  1  NA    16.4 395.18
## 257 0.01538 90.0 3.75    0 0.3940 7.454  34.2 6.3361 NA 244    15.9 386.34
## 258 0.61154 20.0   NA    0     NA 8.704  86.9 1.8010  5 264      NA 389.70
## 259 0.66351 20.0 3.97    0 0.6470 7.333 100.0 1.8946  5 264    13.0 383.29
## 260 0.65665 20.0 3.97    0 0.6470 6.842 100.0 2.0107  5  NA    13.0 391.93
## 261 0.54011 20.0   NA    0 0.6470 7.203  81.8 2.1121  5 264    13.0 392.80
## 262 0.53412 20.0 3.97    0 0.6470 7.520    NA 2.1398  5 264    13.0     NA
## 263      NA 20.0 3.97    0 0.6470 8.398  91.5 2.2885  5 264    13.0 386.86
## 264 0.82526 20.0 3.97    0 0.6470 7.327  94.5 2.0788  5 264      NA 393.42
## 265 0.55007 20.0 3.97    0 0.6470    NA    NA 1.9301  5 264    13.0     NA
## 266 0.76162 20.0 3.97    0 0.6470 5.560  62.8 1.9865  5 264    13.0 392.40
## 267 0.78570 20.0 3.97    0 0.6470 7.014  84.6 2.1329  5  NA    13.0     NA
## 268 0.57834   NA   NA    0 0.5750 8.297  67.0 2.4216  5 264    13.0 384.54
## 269 0.54050 20.0   NA    0 0.5750 7.470  52.6 2.8720  5 264    13.0 390.30
## 270 0.09065 20.0 6.96    1 0.4640 5.920  61.5 3.9175  3 223    18.6 391.34
## 271 0.29916 20.0 6.96    0 0.4640 5.856  42.1 4.4290  3 223    18.6 388.65
## 272 0.16211 20.0 6.96    0 0.4640 6.240    NA 4.4290  3 223    18.6 396.90
## 273 0.11460 20.0 6.96    0 0.4640 6.538  58.7 3.9175  3  NA    18.6 394.96
## 274      NA 20.0 6.96    1 0.4640 7.691  51.8 4.3665  3 223    18.6 390.77
## 275 0.05644 40.0 6.41    1     NA    NA  32.9 4.0776  4  NA    17.6 396.90
## 276 0.09604   NA 6.41    0 0.4470    NA  42.8 4.2673  4 254    17.6 396.90
## 277 0.10469 40.0 6.41    1 0.4470 7.267  49.0 4.7872  4 254      NA 389.25
## 278 0.06127   NA 6.41   NA 0.4470 6.826  27.6 4.8628  4 254    17.6 393.45
## 279 0.07978   NA 6.41    0 0.4470 6.482    NA 4.1403  4 254    17.6 396.90
## 280 0.21038 20.0 3.33    0     NA 6.812  32.2 4.1007  5 216    14.9 396.90
## 281 0.03578 20.0 3.33    0 0.4429 7.820  64.5     NA  5  NA    14.9 387.31
## 282 0.03705   NA 3.33    0 0.4429    NA  37.2     NA  5 216    14.9 392.23
```

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## 283  0.06129 20.0  3.33    1 0.4429 7.645  49.7  5.2119   5  NA    14.9 377.07
## 284  0.01501 90.0    NA    1 0.4010 7.923  24.8  5.8850   1 198    13.6 395.52
## 285  0.00906 90.0  2.97    0 0.4000 7.088  20.8      NA   1 285    15.3 394.72
## 286  0.01096 55.0    NA    0 0.3890 6.453  31.9  7.3073   1 300      NA 394.72
## 287  0.01965 80.0  1.76    0 0.3850    NA  31.5  9.0892   1 241    18.2 341.60
## 288       NA   NA    NA    0 0.4050 6.209  31.3  7.3172  NA 293    16.6 396.90
## 289  0.04590 52.5  5.32    0 0.4050 6.315  45.6  7.3172   6 293    16.6 396.90
## 290  0.04297 52.5  5.32    0 0.4050 6.565  22.9  7.3172   6 293    16.6     NA
## 291       NA 80.0  4.95   NA 0.4110 6.861    NA      NA   4 245    19.2 396.90
## 292  0.07886 80.0  4.95   NA 0.4110 7.148  27.7  5.1167   4 245      NA 396.90
## 293  0.03615 80.0  4.95    0 0.4110 6.630  23.4  5.1167   4 245    19.2 396.90
## 294  0.08265  0.0 13.92    0 0.4370 6.127  18.4  5.5027   4 289    16.0 396.90
## 295  0.08199  0.0 13.92    0     NA 6.009  42.3  5.5027   4 289    16.0 396.90
## 296  0.12932  0.0 13.92    0     NA 6.678  31.1  5.9604   4 289    16.0 396.90
## 297  0.05372  0.0 13.92    0 0.4370 6.549  51.0      NA   4 289    16.0 392.85
## 298  0.14103  0.0 13.92   NA 0.4370 5.790  58.0  6.3200   4 289    16.0 396.90
## 299  0.06466 70.0  2.24    0 0.4000 6.345    NA  7.8278   5 358    14.8     NA
## 300  0.05561 70.0  2.24    0     NA 7.041  10.0  7.8278   5 358    14.8 371.58
## 301  0.04417 70.0  2.24   NA 0.4000 6.871  47.4  7.8278   5 358    14.8 390.86
## 302  0.03537 34.0  6.09    0 0.4330 6.590  40.4      NA   7 329      NA 395.75
## 303       NA 34.0  6.09    0 0.4330 6.495  18.4  5.4917   7 329    16.1 383.61
## 304  0.10000 34.0  6.09   NA 0.4330 6.982  17.7  5.4917  NA 329      NA 390.43
## 305       NA 33.0    NA    0 0.4720 7.236  41.1  4.0220  NA 222    18.4 393.68
## 306       NA 33.0  2.18   NA 0.4720 6.616  58.1  3.3700  NA 222      NA 393.36
## 307  0.07503 33.0  2.18    0     NA 7.420  71.9  3.0992   7 222    18.4 396.90
## 308  0.04932 33.0  2.18    0 0.4720 6.849  70.3  3.1827   7 222    18.4 396.90
## 309  0.49298  0.0  9.90    0     NA 6.635  82.5  3.3175   4 304      NA 396.90
## 310  0.34940  0.0  9.90    0 0.5440 5.972  76.7  3.1025   4 304    18.4 396.24
## 311  2.63548  0.0  9.90    0 0.5440 4.973    NA  2.5194   4 304    18.4 350.45
## 312  0.79041  0.0  9.90    0 0.5440 6.122  52.8  2.6403   4 304    18.4 396.90
## 313       NA  0.0  9.90   NA 0.5440 6.023  90.4  2.8340   4 304    18.4 396.30
## 314  0.26938  0.0  9.90    0     NA 6.266  82.8  3.2628   4 304    18.4 393.39
## 315  0.36920  0.0  9.90   NA 0.5440 6.567  87.3  3.6023   4 304      NA 395.69
## 316  0.25356  0.0  9.90   NA     NA 5.705  77.7  3.9450   4 304    18.4 396.42
## 317  0.31827  0.0  9.90    0 0.5440 5.914  83.2  3.9986   4 304    18.4 390.70
## 318  0.24522  0.0  9.90    0 0.5440 5.782  71.7  4.0317  NA 304    18.4 396.90
## 319  0.40202  0.0  9.90    0 0.5440 6.382  67.2  3.5325   4 304    18.4 395.21
## 320  0.47547  0.0  9.90    0 0.5440 6.113    NA  4.0019   4 304    18.4 396.23
## 321  0.16760   NA  7.38    0     NA 6.426    NA  4.5404   5 287      NA 396.90
## 322  0.18159  0.0  7.38    0 0.4930 6.376  54.3  4.5404   5 287    19.6 396.90
## 323  0.35114  0.0    NA    0 0.4930 6.041    NA  4.7211   5 287    19.6 396.90
## 324  0.28392  0.0  7.38    0 0.4930 5.708    NA  4.7211   5 287    19.6 391.13
## 325  0.34109  0.0  7.38   NA 0.4930 6.415  40.1  4.7211   5 287    19.6     NA
## 326  0.19186  0.0  7.38    0 0.4930 6.431  14.7  5.4159   5 287    19.6 393.68
## 327  0.30347  0.0  7.38    0 0.4930 6.312  28.9  5.4159   5  NA    19.6 396.90
## 328  0.24103   NA  7.38    0     NA 6.083  43.7  5.4159   5 287    19.6 396.90
## 329  0.06617   NA    NA    0 0.4600 5.868  25.8  5.2146   4 430    16.9 382.44
## 330  0.06724  0.0  3.24    0 0.4600 6.333  17.2  5.2146   4  NA    16.9     NA
## 331  0.04544  0.0    NA    0 0.4600 6.144  32.2  5.8736   4 430    16.9     NA
## 332  0.05023 35.0  6.06    0 0.4379 5.706  28.4  6.6407   1 304    16.9 394.02
## 333  0.03466 35.0  6.06   NA 0.4379 6.031  23.3      NA   1 304    16.9 362.25
## 334  0.05083  0.0  5.19    0     NA 6.316  38.1  6.4584   5 224    20.2 389.71
## 335  0.03738  0.0  5.19    0 0.5150 6.310  38.5  6.4584   5 224    20.2 389.40
## 336       NA  0.0  5.19    0 0.5150 6.037  34.5  5.9853   5 224    20.2 396.90
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## 337  0.03427   0.0  5.19    0 0.5150 5.869  46.3  5.2311   5 224    20.2 396.90
## 338  0.03041   0.0  5.19    0 0.5150 5.895  59.6  5.6150   5 224      NA     NA
## 339  0.03306   0.0  5.19    0 0.5150 6.059  37.3  4.8122   5 224    20.2 396.14
## 340       NA   0.0  5.19    0 0.5150 5.985  45.4  4.8122   5 224    20.2 396.90
## 341       NA    NA    NA    0 0.5150 5.968  58.5      NA   5 224    20.2 396.90
## 342  0.01301    NA  1.52   NA 0.4420 7.241  49.3  7.0379   1 284    15.5 394.74
## 343       NA    NA  1.89   NA 0.5180    NA  59.7  6.2669   1 422    15.9 389.96
## 344  0.02543  55.0  3.78    0 0.4840 6.696  56.4  5.7321   5 370    17.6 396.90
## 345  0.03049  55.0  3.78    0 0.4840 6.874  28.1  6.4654   5 370    17.6 387.97
## 346  0.03113   0.0  4.39    0 0.4420 6.014  48.5  8.0136  NA 352    18.8 385.64
## 347  0.06162   0.0  4.39    0     NA 5.898  52.3  8.0136  NA 352    18.8 364.61
## 348  0.01870  85.0  4.15    0 0.4290 6.516  27.7  8.5353   4 351    17.9 392.43
## 349  0.01501  80.0  2.01   NA     NA 6.635  29.7  8.3440   4 280    17.0     NA
## 350  0.02899  40.0  1.25    0 0.4290 6.939    NA  8.7921   1  NA    19.7 389.85
## 351  0.06211  40.0  1.25    0     NA 6.490  44.4  8.7921   1 335    19.7 396.90
## 352  0.07950  60.0    NA    0 0.4110 6.579  35.9      NA   4 411    18.3 370.78
## 353  0.07244  60.0  1.69    0     NA 5.884  18.5 10.7103   4 411    18.3     NA
## 354  0.01709  90.0  2.02    0 0.4100 6.728    NA 12.1265   5 187      NA 384.46
## 355  0.04301  80.0  1.91    0 0.4130 5.663  21.9 10.5857   4 334    22.0 382.80
## 356  0.10659  80.0  1.91   NA 0.4130 5.936  19.5 10.5857   4  NA    22.0 376.04
## 357  8.98296    NA 18.10    1 0.7700 6.212  97.4  2.1222  24 666    20.2 377.73
## 358  3.84970   0.0 18.10    1 0.7700    NA    NA  2.5052  24 666    20.2 391.34
## 359  5.20177    NA 18.10    1 0.7700 6.127  83.4  2.7227  24 666    20.2 395.43
## 360  4.26131   0.0 18.10    0 0.7700 6.112  81.3  2.5091  24 666    20.2 390.74
## 361  4.54192   0.0 18.10    0 0.7700 6.398  88.0  2.5182  24 666    20.2 374.56
## 362  3.83684   0.0    NA   NA 0.7700    NA  91.1  2.2955  24 666    20.2 350.65
## 363  3.67822   0.0 18.10    0 0.7700 5.362  96.2  2.1036  24 666    20.2 380.79
## 364  4.22239    NA 18.10    1 0.7700 5.803  89.0  1.9047  24 666    20.2 353.04
## 365       NA   0.0    NA    1 0.7180    NA  82.9  1.9047  24 666    20.2 354.55
## 366       NA    NA 18.10    0 0.7180 3.561    NA  1.6132  NA 666      NA 354.70
## 367  3.69695   0.0 18.10    0 0.7180 4.963  91.4  1.7523  24 666    20.2 316.03
## 368 13.52220   0.0 18.10    0 0.6310    NA 100.0  1.5106  24 666    20.2 131.42
## 369  4.89822   0.0 18.10    0 0.6310 4.970 100.0  1.3325  NA 666    20.2 375.52
## 370  5.66998   0.0 18.10    1 0.6310 6.683  96.8  1.3567  24 666    20.2 375.33
## 371  6.53876   0.0 18.10    1 0.6310 7.016  97.5  1.2024  24 666    20.2 392.05
## 372  9.23230   0.0 18.10   NA 0.6310 6.216 100.0  1.1691  24 666    20.2 366.15
## 373  8.26725   0.0 18.10    1 0.6680 5.875  89.6  1.1296  NA 666      NA 347.88
## 374 11.10810   0.0    NA    0 0.6680 4.906 100.0  1.1742  24 666    20.2 396.90
## 375 18.49820   0.0 18.10    0 0.6680 4.138 100.0  1.1370  24 666    20.2 396.90
## 376 19.60910   0.0 18.10    0 0.6710 7.313  97.9  1.3163  24  NA    20.2 396.90
## 377 15.28800    NA 18.10    0 0.6710 6.649  93.3  1.3449  24 666    20.2 363.02
## 378  9.82349   0.0 18.10    0 0.6710 6.794  98.8      NA  24 666    20.2 396.90
## 379 23.64820   0.0 18.10    0 0.6710    NA  96.2  1.3861  24 666    20.2 396.90
## 380       NA   0.0 18.10    0 0.6710 6.223 100.0  1.3861  NA 666    20.2 393.74
## 381 88.97620    NA 18.10    0 0.6710 6.968  91.9  1.4165  24 666    20.2 396.90
## 382 15.87440   0.0    NA    0 0.6710    NA  99.1  1.5192  24 666      NA 396.90
## 383  9.18702   0.0    NA    0 0.7000 5.536 100.0  1.5804  24 666    20.2 396.90
## 384  7.99248   0.0 18.10    0 0.7000    NA 100.0  1.5331  24 666    20.2 396.90
## 385 20.08490   0.0 18.10    0 0.7000 4.368  91.2  1.4395  24 666    20.2 285.83
## 386 16.81180   0.0 18.10    0 0.7000 5.277  98.1  1.4261  24 666    20.2 396.90
## 387 24.39380   0.0 18.10    0 0.7000 4.652 100.0  1.4672  24 666    20.2 396.90
## 388 22.59710   0.0    NA    0     NA 5.000  89.5  1.5184  24 666    20.2 396.90
## 389 14.33370   0.0 18.10    0 0.7000 4.880 100.0  1.5895  24 666    20.2 372.92
## 390  8.15174    NA 18.10    0 0.7000 5.390  98.9  1.7281  24 666    20.2 396.90
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## 391  6.96215   0.0 18.10   NA 0.7000    NA  97.0  1.9265  24 666     20.2 394.43
## 392  5.29305   0.0    NA    0     NA 6.051  82.5  2.1678  24 666     20.2 378.38
## 393 11.57790   0.0 18.10    0 0.7000 5.036  97.0  1.7700  24 666       NA 396.90
## 394  8.64476    NA 18.10    0 0.6930 6.193  92.6  1.7912  24 666     20.2 396.90
## 395 13.35980   0.0 18.10    0 0.6930 5.887    NA  1.7821  24 666     20.2 396.90
## 396  8.71675    NA 18.10    0     NA    NA  98.8  1.7257  24 666     20.2 391.98
## 397  5.87205   0.0 18.10    0 0.6930 6.405  96.0  1.6768  24 666     20.2 396.90
## 398  7.67202   0.0 18.10   NA 0.6930 5.747  98.9  1.6334  24 666       NA 393.10
## 399 38.35180   0.0 18.10    0 0.6930 5.453 100.0      NA  24 666     20.2 396.90
## 400  9.91655   0.0 18.10    0 0.6930 5.852  77.8  1.5004  24 666     20.2 338.16
## 401 25.04610   0.0 18.10    0 0.6930 5.987 100.0  1.5888  24  NA     20.2 396.90
## 402 14.23620   0.0 18.10    0 0.6930 6.343 100.0  1.5741  24 666       NA     NA
## 403  9.59571   0.0 18.10    0 0.6930    NA 100.0  1.6390  24 666     20.2 376.11
## 404 24.80170    NA 18.10    0 0.6930 5.349  96.0      NA  24 666     20.2     NA
## 405 41.52920   0.0 18.10    0 0.6930    NA  85.4  1.6074  24 666     20.2 329.46
## 406 67.92080   0.0 18.10    0 0.6930    NA    NA  1.4254  24 666       NA     NA
## 407 20.71620   0.0 18.10    0 0.6590 4.138 100.0  1.1781  24 666       NA 370.22
## 408 11.95110   0.0 18.10    0 0.6590 5.608 100.0  1.2852  24 666     20.2 332.09
## 409  7.40389   0.0 18.10    0 0.5970 5.617  97.9  1.4547  24 666     20.2 314.64
## 410 14.43830   0.0 18.10    0     NA 6.852    NA  1.4655  24 666     20.2 179.36
## 411 51.13580   0.0 18.10    0 0.5970 5.757 100.0  1.4130  24 666     20.2   2.60
## 412       NA   0.0    NA    0     NA 6.657 100.0  1.5275  24 666     20.2  35.05
## 413 18.81100   0.0 18.10    0     NA 4.628    NA  1.5539  24 666     20.2  28.79
## 414 28.65580   0.0 18.10    0 0.5970 5.155 100.0  1.5894  NA 666       NA 210.97
## 415 45.74610   0.0 18.10    0 0.6930    NA 100.0  1.6582  24 666     20.2  88.27
## 416 18.08460   0.0 18.10    0 0.6790 6.434 100.0  1.8347  24 666       NA  27.25
## 417 10.83420   0.0 18.10    0 0.6790 6.782  90.8      NA  24 666     20.2  21.57
## 418 25.94060    NA 18.10   NA 0.6790    NA  89.1      NA  24 666     20.2     NA
## 419 73.53410   0.0    NA    0 0.6790 5.957 100.0  1.8026  24 666     20.2  16.45
## 420 11.81230   0.0 18.10    0 0.7180 6.824  76.5      NA  24 666     20.2  48.45
## 421 11.08740    NA 18.10    0 0.7180 6.411 100.0  1.8589  NA 666     20.2 318.75
## 422       NA   0.0 18.10    0 0.7180 6.006  95.3  1.8746  24 666     20.2 319.98
## 423 12.04820   0.0 18.10    0     NA 5.648  87.6  1.9512  24 666     20.2 291.55
## 424  7.05042   0.0 18.10    0 0.6140 6.103  85.1  2.0218  24 666     20.2     NA
## 425       NA   0.0 18.10    0     NA 5.565  70.6      NA  24 666     20.2   3.65
## 426 15.86030   0.0    NA    0 0.6790 5.896  95.4  1.9096  24 666     20.2   7.68
## 427       NA    NA 18.10    0 0.5840 5.837    NA  1.9976  NA 666     20.2  24.65
## 428 37.66190   0.0 18.10    0 0.6790 6.202    NA  1.8629  24 666     20.2  18.82
## 429  7.36711   0.0 18.10    0 0.6790 6.193  78.1  1.9356  24 666     20.2  96.73
## 430  9.33889   0.0 18.10    0 0.6790 6.380  95.6  1.9682  24 666     20.2  60.72
## 431  8.49213   0.0 18.10    0 0.5840 6.348  86.1  2.0527  24 666     20.2  83.45
## 432 10.06230   0.0 18.10    0 0.5840 6.833  94.3  2.0882  24 666     20.2     NA
## 433       NA   0.0 18.10    0 0.5840 6.425  74.8  2.2004  24 666     20.2     NA
## 434  5.58107    NA 18.10    0 0.7130 6.436  87.9  2.3158  24 666     20.2 100.19
## 435 13.91340   0.0 18.10    0 0.7130 6.208  95.0  2.2222  24 666     20.2 100.63
## 436 11.16040   0.0 18.10    0     NA 6.629  94.6  2.1247  24 666     20.2 109.85
## 437 14.42080   0.0 18.10    0 0.7400 6.461  93.3  2.0026  24 666     20.2     NA
## 438 15.17720   0.0 18.10    0 0.7400 6.152 100.0  1.9142  24 666     20.2   9.32
## 439 13.67810   0.0 18.10    0 0.7400 5.935  87.9  1.8206  NA 666     20.2  68.95
## 440       NA   0.0 18.10    0 0.7400 5.627  93.9  1.8172  NA 666     20.2 396.90
## 441 22.05110   0.0 18.10    0 0.7400 5.818  92.4  1.8662  NA 666     20.2 391.45
## 442  9.72418   0.0 18.10    0 0.7400 6.406  97.2  2.0651  24 666     20.2     NA
## 443  5.66637   0.0 18.10    0 0.7400    NA 100.0  2.0048  24 666     20.2 395.69
## 444  9.96654   0.0 18.10    0 0.7400 6.485 100.0  1.9784  24 666     20.2     NA
```

```
## 445 12.80230   0.0 18.10    0 0.7400 5.854  96.6  1.8956  24 666    20.2 240.52
## 446 10.67180   0.0    NA    0 0.7400    NA  94.8  1.9879  24 666    20.2  43.06
## 447  6.28807   0.0 18.10    0 0.7400 6.341  96.4  2.0720  24 666      NA 318.01
## 448  9.92485   0.0    NA    0 0.7400 6.251  96.6  2.1980  24 666    20.2     NA
## 449  9.32909   0.0 18.10   NA     NA 6.185  98.7  2.2616  24 666    20.2 396.90
## 450       NA   0.0 18.10    0     NA 6.417    NA  2.1850  24  NA    20.2 304.21
## 451       NA    NA 18.10    0 0.7130 6.749  92.6  2.3236  24 666    20.2   0.32
## 452  5.44114   0.0 18.10    0 0.7130 6.655  98.2  2.3552  24 666    20.2 355.29
## 453       NA   0.0 18.10    0 0.7130 6.297  91.8  2.3682  24 666    20.2     NA
## 454  8.24809   0.0    NA    0 0.7130 7.393  99.3  2.4527  24 666    20.2     NA
## 455  9.51363   0.0    NA    0 0.7130    NA  94.1  2.4961  24 666    20.2   6.68
## 456  4.75237   0.0 18.10    0 0.7130 6.525  86.5  2.4358  24 666      NA     NA
## 457  4.66883    NA 18.10    0 0.7130 5.976  87.9  2.5806  24 666    20.2  10.48
## 458  8.20058   0.0 18.10    0 0.7130 5.936    NA  2.7792  24 666    20.2   3.50
## 459  7.75223   0.0 18.10    0 0.7130 6.301  83.7  2.7831  NA 666    20.2 272.21
## 460  6.80117   0.0 18.10    0 0.7130 6.081  84.4  2.7175  24 666    20.2 396.90
## 461  4.81213   0.0 18.10    0 0.7130 6.701  90.0  2.5975  24 666    20.2 255.23
## 462       NA   0.0 18.10    0 0.7130    NA    NA  2.5671  24 666    20.2 391.43
## 463  6.65492    NA 18.10   NA 0.7130 6.317  83.0  2.7344  24 666    20.2     NA
## 464  5.82115   0.0 18.10    0 0.7130 6.513  89.9  2.8016  24 666    20.2 393.82
## 465  7.83932   0.0    NA    0 0.6550 6.209  65.4  2.9634  24 666    20.2 396.90
## 466  3.16360   0.0 18.10    0 0.6550 5.759  48.2  3.0665  24 666    20.2 334.40
## 467       NA   0.0 18.10    0 0.6550    NA  84.7  2.8715  24 666    20.2  22.01
## 468  4.42228   0.0 18.10    0 0.5840 6.003  94.5      NA  24 666    20.2 331.29
## 469 15.57570   0.0 18.10    0 0.5800 5.926  71.0  2.9084  24 666    20.2 368.74
## 470 13.07510   0.0    NA   NA 0.5800 5.713  56.7  2.8237  24 666    20.2 396.90
## 471  4.34879   0.0 18.10    0     NA 6.167  84.0  3.0334  24 666    20.2 396.90
## 472  4.03841   0.0 18.10    0     NA 6.229  90.7  3.0993  24 666    20.2 395.33
## 473  3.56868   0.0 18.10    0 0.5800 6.437  75.0  2.8965  24 666    20.2     NA
## 474  4.64689   0.0 18.10    0 0.6140    NA  67.6  2.5329  24 666    20.2 374.68
## 475  8.05579   0.0 18.10    0 0.5840 5.427  95.4  2.4298  24 666    20.2 352.58
## 476       NA   0.0 18.10    0 0.5840 6.162  97.4  2.2060  24 666    20.2 302.76
## 477       NA   0.0 18.10    0 0.6140    NA  93.6  2.3053  NA 666    20.2 396.21
## 478 15.02340   0.0    NA    0     NA 5.304  97.3  2.1007  24 666    20.2 349.48
## 479       NA   0.0 18.10    0 0.6140    NA    NA  2.1705  NA 666    20.2 379.70
## 480 14.33370   0.0    NA    0 0.6140 6.229  88.0  1.9512  24 666    20.2 383.32
## 481  5.82401   0.0 18.10    0 0.5320 6.242  64.7  3.4242  24 666    20.2 396.90
## 482  5.70818    NA 18.10    0 0.5320 6.750  74.9  3.3317  24 666    20.2     NA
## 483  5.73116   0.0 18.10    0 0.5320 7.061  77.0      NA  NA 666    20.2 395.28
## 484  2.81838   0.0 18.10    0 0.5320 5.762  40.3  4.0983  24 666    20.2 392.92
## 485  2.37857   0.0 18.10    0 0.5830 5.871  41.9  3.7240  24 666    20.2 370.73
## 486  3.67367   0.0 18.10    0 0.5830 6.312  51.9  3.9917  24 666    20.2 388.62
## 487  5.69175   0.0 18.10    0 0.5830 6.114  79.8      NA  NA 666    20.2 392.68
## 488  4.83567   0.0 18.10    0 0.5830 5.905  53.2  3.1523  24 666    20.2 388.22
## 489  0.15086   0.0 27.74    0     NA 5.454  92.7  1.8209   4  NA    20.1     NA
## 490  0.18337   0.0 27.74    0 0.6090 5.414  98.3  1.7554   4 711    20.1 344.05
## 491  0.20746   0.0 27.74    0 0.6090 5.093  98.0  1.8226  NA 711    20.1 318.43
## 492  0.10574   0.0 27.74    0 0.6090 5.983  98.8  1.8681   4 711    20.1 390.11
## 493  0.11132   0.0 27.74    0 0.6090 5.983  83.5  2.1099   4 711    20.1     NA
## 494  0.17331   0.0  9.69    0 0.5850 5.707  54.0  2.3817   6 391    19.2 396.90
## 495  0.27957   0.0  9.69    0 0.5850 5.926  42.6  2.3817   6 391    19.2 396.90
## 496  0.17899   0.0    NA    0 0.5850 5.670    NA  2.7986   6 391      NA 393.29
## 497  0.28960   0.0  9.69    0 0.5850 5.390  72.9  2.7986   6 391    19.2 396.90
## 498  0.26838   0.0  9.69    0 0.5850 5.794  70.6  2.8927   6 391    19.2 396.90
```

```
## 499  0.23912   0.0   9.69    0 0.5850 6.019  65.3  2.4091   6 391    19.2 396.90
## 500  0.17783   0.0   9.69    0 0.5850 5.569  73.5  2.3999   6 391    19.2 395.77
## 501  0.22438   0.0     NA    0 0.5850 6.027  79.7      NA   6 391    19.2 396.90
## 502  0.06263   0.0 11.93    0 0.5730 6.593  69.1  2.4786  NA 273    21.0 391.99
## 503  0.04527   0.0 11.93    0 0.5730 6.120  76.7  2.2875   1 273    21.0 396.90
## 504  0.06076   0.0 11.93    0 0.5730 6.976  91.0  2.1675   1 273      NA 396.90
## 505  0.10959   0.0 11.93   NA     NA 6.794  89.3  2.3889   1  NA    21.0 393.45
## 506  0.04741    NA 11.93   NA 0.5730 6.030  80.8  2.5050   1 273    21.0 396.90
##     lstat
## 1      NA
## 2    9.14
## 3    4.03
## 4    2.94
## 5    5.33
## 6    5.21
## 7      NA
## 8   19.15
## 9   29.93
## 10  17.10
## 11     NA
## 12  13.27
## 13  15.71
## 14   8.26
## 15  10.26
## 16   8.47
## 17   6.58
## 18  14.67
## 19  11.69
## 20  11.28
## 21  21.02
## 22     NA
## 23  18.72
## 24  19.88
## 25  16.30
## 26  16.51
## 27  14.81
## 28  17.28
## 29  12.80
## 30  11.98
## 31  22.60
## 32  13.04
## 33  27.71
## 34  18.35
## 35  20.34
## 36   9.68
## 37     NA
## 38   8.77
## 39     NA
## 40   4.32
## 41   1.98
## 42   4.84
## 43   5.81
## 44   7.44
## 45   9.55
```

```
## 46  10.21
## 47  14.15
## 48  18.80
## 49  30.81
## 50  16.20
## 51  13.45
## 52   9.43
## 53   5.28
## 54   8.43
## 55  14.80
## 56   4.81
## 57   5.77
## 58   3.95
## 59   6.86
## 60   9.22
## 61  13.15
## 62  14.44
## 63   6.73
## 64   9.50
## 65   8.05
## 66   4.67
## 67  10.24
## 68   8.10
## 69  13.09
## 70   8.79
## 71   6.72
## 72   9.88
## 73   5.52
## 74   7.54
## 75   6.78
## 76   8.94
## 77  11.97
## 78  10.27
## 79  12.34
## 80   9.10
## 81   5.29
## 82   7.22
## 83     NA
## 84   7.51
## 85   9.62
## 86   6.53
## 87  12.86
## 88   8.44
## 89   5.50
## 90   5.70
## 91   8.81
## 92   8.20
## 93     NA
## 94   6.21
## 95  10.59
## 96   6.65
## 97  11.34
## 98   4.21
## 99   3.57
```

```
## 100  6.19
## 101  9.42
## 102  7.67
## 103 10.63
## 104 13.44
## 105 12.33
## 106 16.47
## 107 18.66
## 108 14.09
## 109 12.27
## 110 15.55
## 111 13.00
## 112 10.16
## 113 16.21
## 114    NA
## 115 10.45
## 116 15.76
## 117 12.04
## 118 10.30
## 119 15.37
## 120 13.61
## 121 14.37
## 122 14.27
## 123 17.93
## 124 25.41
## 125 17.58
## 126    NA
## 127 27.26
## 128 17.19
## 129 15.39
## 130 18.34
## 131 12.60
## 132 12.26
## 133 11.12
## 134 15.03
## 135 17.31
## 136 16.96
## 137 16.90
## 138 14.59
## 139 21.32
## 140 18.46
## 141 24.16
## 142 34.41
## 143 26.82
## 144 26.42
## 145 29.29
## 146 27.80
## 147 16.65
## 148 29.53
## 149 28.32
## 150 21.45
## 151 14.10
## 152    NA
## 153 12.12
```

```
## 154 15.79
## 155 15.12
## 156 15.02
## 157    NA
## 158    NA
## 159  6.43
## 160  7.39
## 161  5.50
## 162  1.73
## 163  1.92
## 164  3.32
## 165 11.64
## 166  9.81
## 167  3.70
## 168 12.14
## 169 11.10
## 170 11.32
## 171 14.43
## 172 12.03
## 173 14.69
## 174    NA
## 175  9.64
## 176  5.33
## 177 10.11
## 178  6.29
## 179  6.92
## 180  5.04
## 181  7.56
## 182  9.45
## 183  4.82
## 184    NA
## 185 13.98
## 186 13.15
## 187  4.45
## 188  6.68
## 189  4.56
## 190  5.39
## 191  5.10
## 192    NA
## 193  2.87
## 194  5.03
## 195  4.38
## 196  2.97
## 197  4.08
## 198  8.61
## 199  6.62
## 200  4.56
## 201  4.45
## 202  7.43
## 203  3.11
## 204  3.81
## 205  2.88
## 206    NA
## 207 10.97
```

```
## 208 18.06
## 209    NA
## 210 23.09
## 211 17.27
## 212 23.98
## 213 16.03
## 214  9.38
## 215 29.55
## 216  9.47
## 217 13.51
## 218  9.69
## 219 17.92
## 220 10.50
## 221  9.71
## 222 21.46
## 223  9.93
## 224  7.60
## 225  4.14
## 226  4.63
## 227  3.13
## 228  6.36
## 229    NA
## 230  3.76
## 231 11.65
## 232  5.25
## 233  2.47
## 234  3.95
## 235  8.05
## 236 10.88
## 237  9.54
## 238  4.73
## 239  6.36
## 240  7.37
## 241 11.38
## 242 12.40
## 243 11.22
## 244  5.19
## 245 12.50
## 246 18.46
## 247  9.16
## 248 10.15
## 249  9.52
## 250  6.56
## 251  5.90
## 252  3.59
## 253  3.53
## 254  3.54
## 255  6.57
## 256  9.25
## 257  3.11
## 258  5.12
## 259  7.79
## 260  6.90
## 261  9.59
```

```
## 262  7.26
## 263  5.91
## 264 11.25
## 265  8.10
## 266 10.45
## 267 14.79
## 268  7.44
## 269  3.16
## 270 13.65
## 271 13.00
## 272  6.59
## 273  7.73
## 274  6.58
## 275  3.53
## 276  2.98
## 277  6.05
## 278  4.16
## 279  7.19
## 280  4.85
## 281  3.76
## 282  4.59
## 283  3.01
## 284  3.16
## 285  7.85
## 286  8.23
## 287    NA
## 288  7.14
## 289  7.60
## 290  9.51
## 291  3.33
## 292  3.56
## 293  4.70
## 294  8.58
## 295 10.40
## 296  6.27
## 297    NA
## 298 15.84
## 299  4.97
## 300  4.74
## 301  6.07
## 302  9.50
## 303    NA
## 304  4.86
## 305  6.93
## 306  8.93
## 307  6.47
## 308  7.53
## 309  4.54
## 310    NA
## 311 12.64
## 312  5.98
## 313 11.72
## 314  7.90
## 315  9.28
```

```
## 316 11.50
## 317 18.33
## 318    NA
## 319 10.36
## 320 12.73
## 321  7.20
## 322  6.87
## 323  7.70
## 324 11.74
## 325  6.12
## 326  5.08
## 327  6.15
## 328 12.79
## 329  9.97
## 330  7.34
## 331  9.09
## 332 12.43
## 333  7.83
## 334    NA
## 335  6.75
## 336  8.01
## 337  9.80
## 338    NA
## 339  8.51
## 340  9.74
## 341    NA
## 342  5.49
## 343  8.65
## 344  7.18
## 345  4.61
## 346 10.53
## 347 12.67
## 348  6.36
## 349  5.99
## 350  5.89
## 351  5.98
## 352    NA
## 353  7.79
## 354  4.50
## 355  8.05
## 356  5.57
## 357 17.60
## 358 13.27
## 359 11.48
## 360 12.67
## 361  7.79
## 362 14.19
## 363 10.19
## 364 14.64
## 365  5.29
## 366  7.12
## 367 14.00
## 368 13.33
## 369  3.26
```

```
## 370  3.73
## 371  2.96
## 372  9.53
## 373  8.88
## 374 34.77
## 375 37.97
## 376 13.44
## 377 23.24
## 378 21.24
## 379 23.69
## 380 21.78
## 381 17.21
## 382 21.08
## 383 23.60
## 384 24.56
## 385 30.63
## 386 30.81
## 387 28.28
## 388 31.99
## 389 30.62
## 390 20.85
## 391 17.11
## 392 18.76
## 393 25.68
## 394 15.17
## 395 16.35
## 396 17.12
## 397 19.37
## 398 19.92
## 399    NA
## 400 29.97
## 401 26.77
## 402 20.32
## 403 20.31
## 404 19.77
## 405 27.38
## 406 22.98
## 407 23.34
## 408 12.13
## 409 26.40
## 410 19.78
## 411 10.11
## 412 21.22
## 413    NA
## 414 20.08
## 415 36.98
## 416 29.05
## 417 25.79
## 418 26.64
## 419 20.62
## 420    NA
## 421 15.02
## 422 15.70
## 423 14.10
```

```
## 424 23.29
## 425 17.16
## 426 24.39
## 427    NA
## 428 14.52
## 429 21.52
## 430 24.08
## 431 17.64
## 432 19.69
## 433 12.03
## 434    NA
## 435 15.17
## 436    NA
## 437 18.05
## 438 26.45
## 439 34.02
## 440 22.88
## 441 22.11
## 442 19.52
## 443 16.59
## 444 18.85
## 445 23.79
## 446 23.98
## 447 17.79
## 448 16.44
## 449 18.13
## 450 19.31
## 451 17.44
## 452 17.73
## 453 17.27
## 454 16.74
## 455 18.71
## 456 18.13
## 457 19.01
## 458 16.94
## 459    NA
## 460 14.70
## 461 16.42
## 462 14.65
## 463 13.99
## 464 10.29
## 465 13.22
## 466 14.13
## 467 17.15
## 468 21.32
## 469 18.13
## 470 14.76
## 471 16.29
## 472 12.87
## 473 14.36
## 474 11.66
## 475 18.14
## 476    NA
## 477 18.68
```

```
## 478    NA
## 479    NA
## 480 13.11
## 481    NA
## 482  7.74
## 483  7.01
## 484 10.42
## 485 13.34
## 486 10.58
## 487 14.98
## 488 11.45
## 489 18.06
## 490 23.97
## 491 29.68
## 492 18.07
## 493 13.35
## 494 12.01
## 495 13.59
## 496 17.60
## 497 21.14
## 498 14.10
## 499 12.92
## 500 15.10
## 501 14.33
## 502  9.67
## 503  9.08
## 504  5.64
## 505  6.48
## 506  7.88
```

Use a random forest modeling procedure to iteratively fill in the NA's by predicting each feature of X using every other feature of X. You need to start by filling in the holes to use RF. So fill them in with the average of the feature.

```
#Getting error while kniting

#pacman::p_load(randomForest)


#n =  nrow(X_fill)
#p =  ncol(X_fill)

#for(i in 1:n){
#  for(j in 1:p){
#    if(is.na(X_fill[i,j])){
#      X_fill_2 = X_fill %>%
#        replace_na(as.list(colMeans(X_fill, na.rm = TRUE)))
#
#      rf_mod = randomForest(X_fill_2[,j] ~., data = X_fill_2, ntree = 100)
#
#      X_fill[i,j] =predict(rf_mod, X_fill_2[i,])
#    }
#  }
#}
```

```
#X_fill
```