Week4_Lab

R Markdown

We’ll continue working with the birds file and practice computing Confidence Intervals for a difference in means and run a one sample t-test. Let’s load the ‘birds’ data.

```
library(tidyverse)
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
## ✔ dplyr     1.1.4     ✔ readr     2.1.5
## ✔ forcats   1.0.0     ✔ stringr   1.5.1
## ✔ ggplot2   3.5.1     ✔ tibble    3.2.1
## ✔ lubridate 1.9.4     ✔ tidyr     1.3.1
## ✔ purrr     1.0.2
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to becom
e errors
```

```
library(data.table)
```

```
##
## Attaching package: 'data.table'
##
## The following objects are masked from 'package:lubridate':
##
##     hour, isoweek, mday, minute, month, quarter, second, wday, week,
##     yday, year
##
## The following objects are masked from 'package:dplyr':
##
##     between, first, last
##
## The following object is masked from 'package:purrr':
##
##     transpose
```

```
suppressWarnings(expr) #supresses warnings
```

```
## function (expr)
## {
##     enexpr(expr)
## }
## <bytecode: 0x00000231d81bbc40>
## <environment: namespace:rlang>
```

```
data <- read_csv("wildlife.csv",show_col_types = FALSE)
```

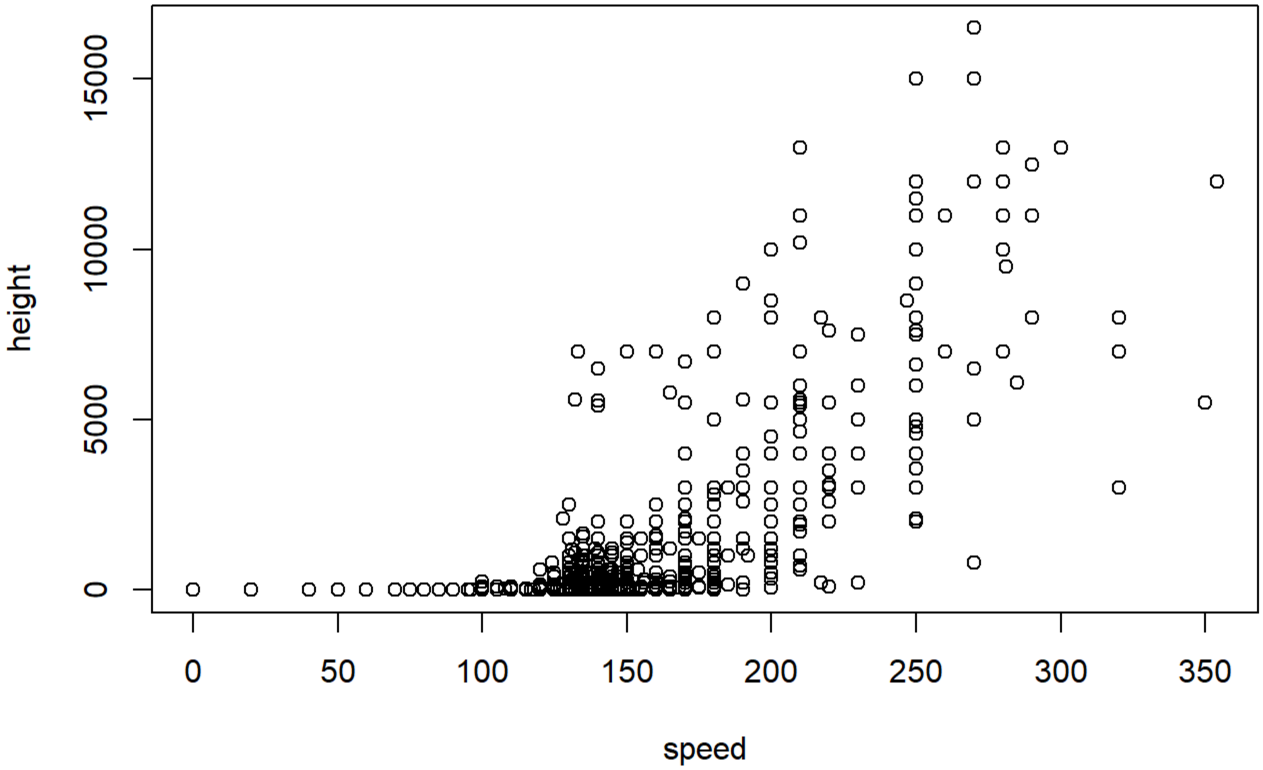
```
## Warning: One or more parsing issues, call `problems()` on your data frame for details,
## e.g.:
##   dat <- vroom(...)
##   problems(dat)
```

```
data<-as.data.table(data)
#head(data)
names(data) <- tolower(names(data)) #convert column names to lower case
```

A little EDA

Perform some descriptives (we did this in one of the prior demos).

```
plot(height~speed, data=data)
```

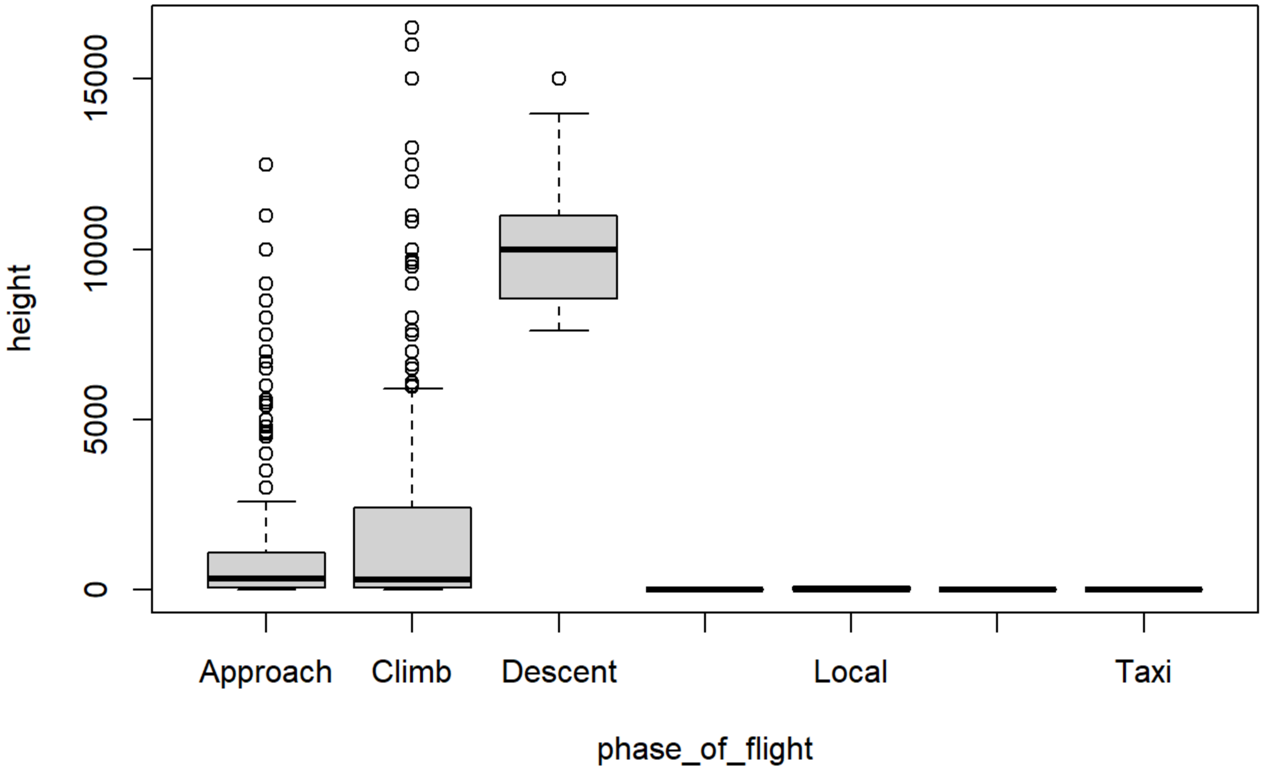


```
summary(data$height)
```

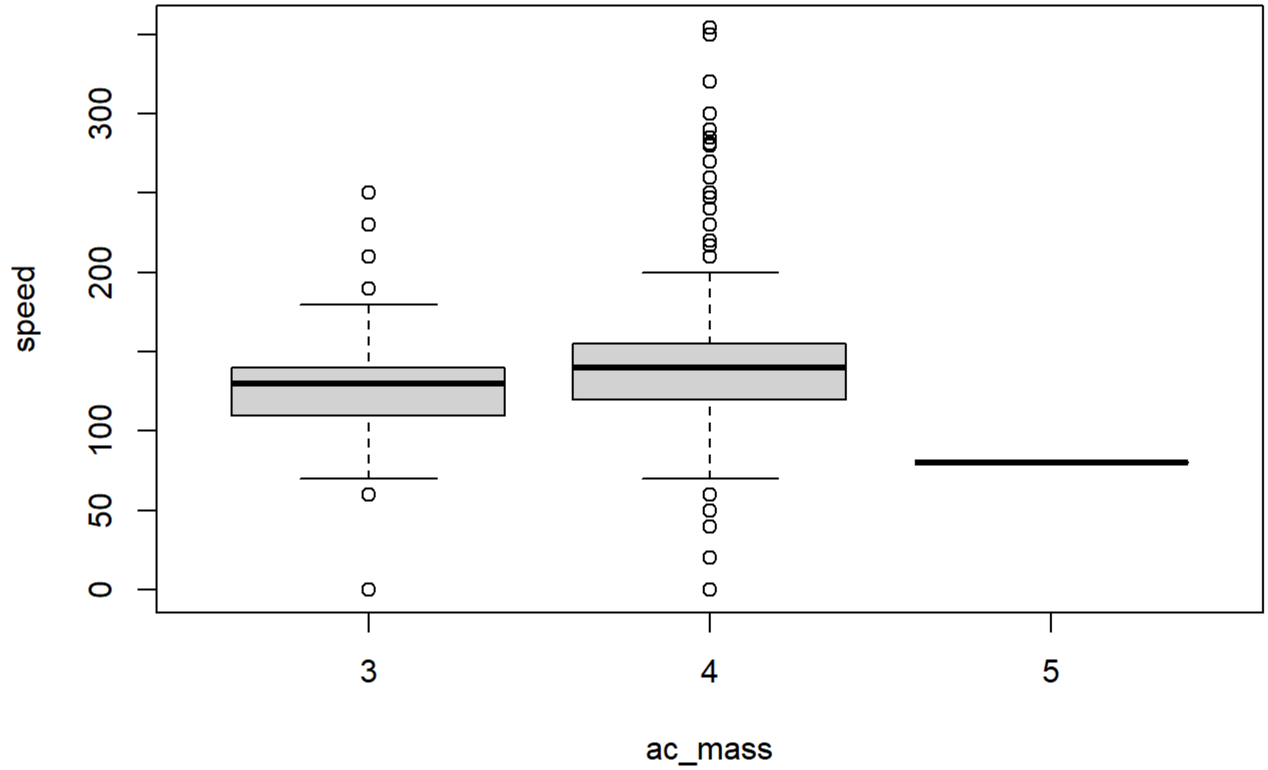
```
##     Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's 
##      0.0     0.0     0.0   487.8    10.0 16500.0    4952
```

Here is a side-by-side box plot by phase of flight and mass of aircraft.

```
boxplot(height~phase_of_flight, data=data)
```



```
boxplot(speed~ac_mass,data=data)
```



Slicing and Dicing Data

Let’s use tapply() to filter our data and only look at aircraft that weigh above 5701 kg or more. We can also see the mean speed and SD for birds were struck.

```
birds_by_amass = data[data$ac_mass  %in% c(3,4), ]

tapply(birds_by_amass$speed, birds_by_amass$num_struck, mean, na.rm=TRUE)
```

```
##        1   11-100     2-10
## 143.3620 146.5000 139.7908
```

```
tapply(birds_by_amass$speed, birds_by_amass$num_struck, sd, na.rm=TRUE)
```

```
##        1   11-100     2-10
## 40.48218 14.38749 35.96126
```

We also need to remove NAs to be able to compute the sample means and standard deviations.

```
no_nas = function(x){
  return(sum(!is.na(x)))
}
summary(birds_by_amass$ac_mass)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##   3.000   4.000   4.000   3.879   4.000   4.000
```

Compute the sample means and SDs

Let’s compute a Confidence interval for difference in means for speed in the reduced data set. We need to compute the sample means and standard deviations first.

```
xbarz = tapply(birds_by_amass$speed, birds_by_amass$ac_mass, mean, na.rm=TRUE)
sez   = tapply(birds_by_amass$speed, birds_by_amass$ac_mass, sd, na.rm=TRUE)/sqrt(tapply(birds_b
y_amass$speed, birds_by_amass$ac_mass, no_nas))
xbarz
```

```
##        3        4 
## 131.2152 144.3458
```

```
sez
```

```
##        3        4 
## 2.873973 1.132058
```

Difference in means and the Standard error of the difference

Compute the difference in means for speed and the standard error of the difference using the z statistic. Having these 2 pieces of information will let us compute the lower and upper part of the interval.

```
diff_meanz = xbarz[2] - xbarz[1]       ## compute the difference in means
se_diff    = sqrt(sez[2]^2+sez[1]^2)   ## compute the standard error of the difference
lower = diff_meanz - 1.96*se_diff      ## lower part of the interval
upper = diff_meanz + 1.96*se_diff      ## upper part of the interval

c(lower, upper)
```

```
##         4         4 
##  7.076421 19.184893
```

Alternatively, you could use a two-sample t-test to compute a difference in means using the base function in R.

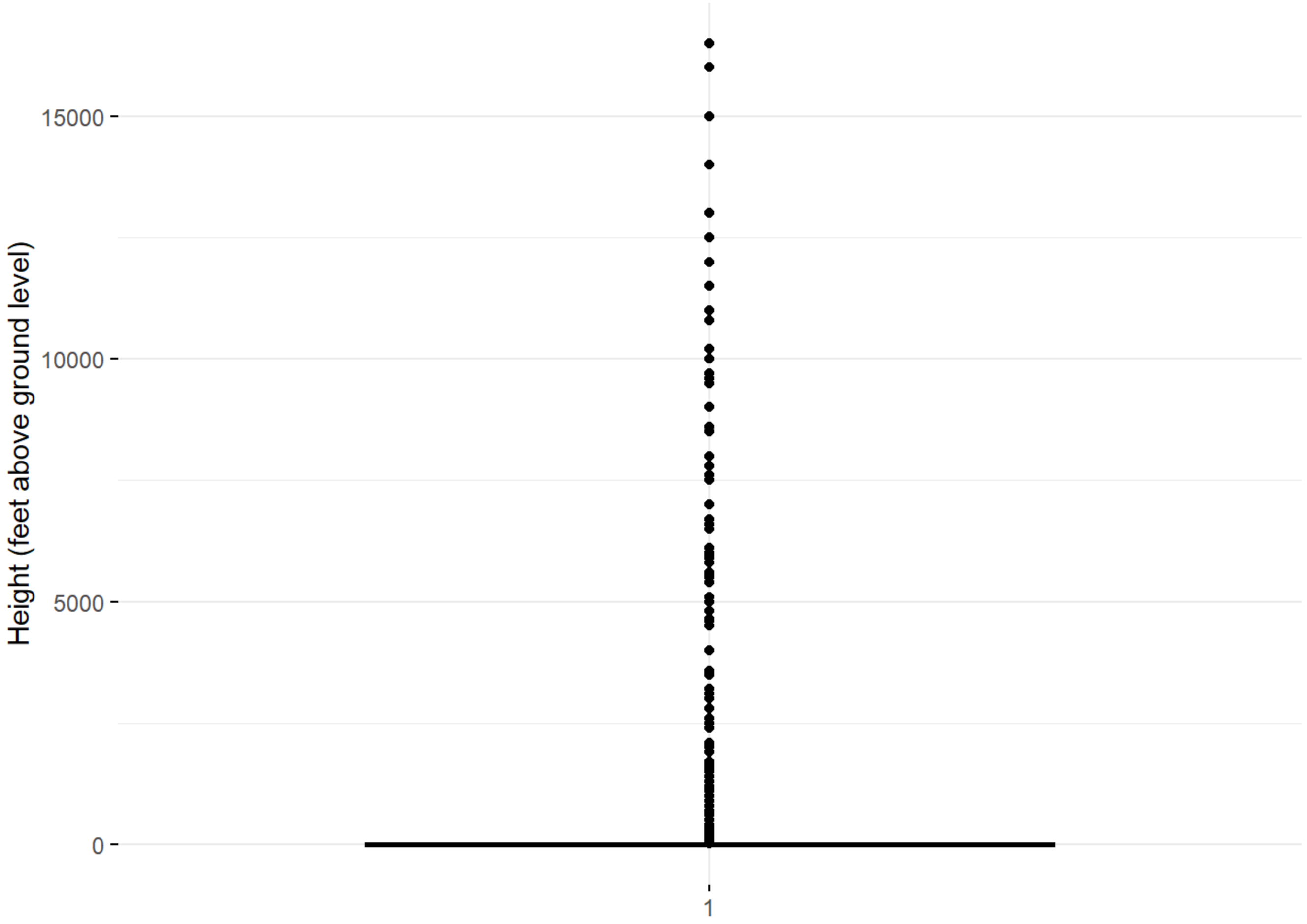
```
t.test(birds_by_amass$height,alternative = "two.sided")   ## gives the 95 percent CI as the default
```

```
##
##  One Sample t-test
##
## data:  birds_by_amass$height
## t = 15.97, df = 3414, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  438.4891 561.2251
## sample estimates:
## mean of x
##  499.8571
```

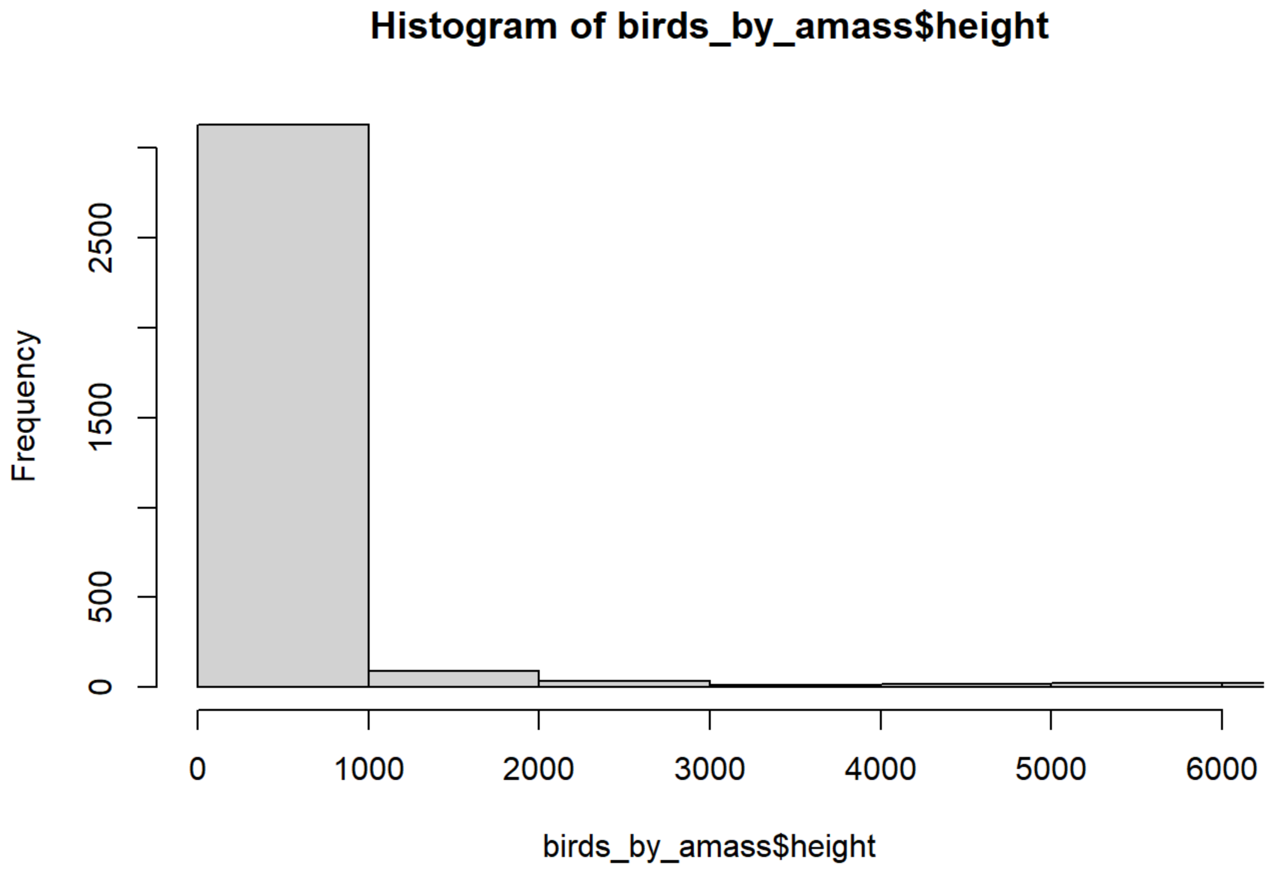
Recall what the height variable looks like…

```
library(ggpubr)
ggboxplot(birds_by_amass$height,
          ylab = "Height (feet above ground level)", xlab = FALSE,
          ggtheme = theme_minimal())
```

```
## Warning: Removed 817 rows containing non-finite outside the scale range
## (`stat_boxplot()`).
```



```
hist(birds_by_amass$height, xlim=c(0,6000))
```



There are a lot of outliers! How do we remove them?

Outlier detection and removal

We can use a statistical method of removing outliers using the inter-quartile range (IQR). We need to meet the assumption of our data being normally distributed (i.e. bell-shaped curve). Since this is not the case for height we wouldn’t implement this method. But, if we wanted to see how it would work, it would be as follows: We’ll use the quantile () function to find the 25th and 75th percentiles of height and the IQR() function will give us the difference between them.

```
Q <- quantile(birds_by_amass$height, probs=c(.25, .75), na.rm = TRUE)
iqr <- IQR(birds_by_amass$height, na.rm = TRUE)
iqr
```

```
## [1] 10
```

Now that we have these two pieces, we can compute the cut-off ranges beyond which the data is considered to be outliers.

```
up <-  Q[2]+1.5*iqr # Upper Range
low<- Q[1]-1.5*iqr # Lower Range
```

Here we actually remove the outliers by extracting the part of the dataset that we need between the upper and lower ranges.

```
new_data_byamass<- subset(birds_by_amass, birds_by_amass$height > (Q[1] - 1.5*iqr) & birds_by_amass$height < (Q[2]+1.5*iqr))
```

There are also other ways of removing outliers. An easier method is probably to use the boxplot () function and which () function to find and remove them from data.

```
boxplot(birds_by_amass$height, plot=FALSE)$out
```

```
##   [1]   200    50   150   800  1000    50  5550  3566   100   700  1500  1500
##  [13]  5000 11000   500  1000 10000   500   300   200    75   100   200   300
##  [25]  8000  3000   300   100  1500   300   100   150   100   100 13000   100
##  [37]  1000   100    50   200  4000    50   500   500   200  1200  1500   500
##  [49]   200  1500   600  9500  2000  1000  1000  3000  1000  1000  2000  1500
##  [61]    50   100  7000   300    50  1000  5600  6000  4000  1200    50  2500
##  [73]   200    50  4000 10800   100  6000  2500   500  7500  4000 12000  7000
##  [85]    50  7000  2000  1700  9000  1700  2100  7500   100   100  7000  1000
##  [97]  2000  1500   400   200  5000  9000   200    75   100   300  1200   600
## [109]  1000  7500 11000  1643  8000 14000    35   300   800 10000  1500  3200
## [121]   100  1000  1570   500  1000  1500  1500   500   600   100   100   500
## [133]  9000   100  9000   100   700  1000   600  3000  7500    50  3000 10000
## [145]    50   100  7000  4000  1000  5800   100   200   500  1174  8500  1000
## [157]    50   500  2000  5000  1100  1000   100    50   200    50  2000   300
## [169]   400   200  1000  2000  2000   300   600   300   400 11000  7000   500
## [181]   500  1500  1500  7000  2000  3000  1000  2000   500   800   100  1500
## [193]    75   500    50  1100    50  4000  5400  2000   100   100  1000    50
## [205]   800    50   400 10000   900   100   150   330   100    50    75    30
## [217]    50  4000   500   500   100   100  1600   400    30  5400   100    50
## [229]  4600  1500  9000 12500   150  2000  2000   400  8000    50   100   200
## [241]  2600  5000   300   800  1000    70   400   200   100   100  3000   100
## [253]  3500  7000    30   500   500 10000   500   400   200    80   100  6000
## [265]    30  4000   100 12000  1000   400  1000   100  1000   900    35  4650
## [277]  1400 13000  6500    50    50   700  5500  1000  6000   500   300  7000
## [289]  3000  1000   100   200   500   600  1000   100   500   700   100   600
## [301]  1500   500    50   200   100  6000  1000   350 11000   300  2500 10000
## [313]  8600  3000   200    50  1200  1000   100 10000  2000   200   200  5500
## [325]   100  7800    50    50    30  1000   250   200   100   200   100  2100
## [337]   800   500   500   200  1500   200    50  1000 10200  1000  7000   800
## [349]  1000  5000  5000 10000  1000 11000   300   700   200  6700  8000   700
## [361]    50    50   100    75    50   200   200  1000    50   100   700   200
## [373]  1200   500  1500  1900   800   400  1000   400    50    60   200   800
## [385]  1000   700    75   150    50   500   100    50    50   300   400   150
## [397]   200   200   100  3000  3000  2000  1200    30  6100  1500   100    50
## [409]    50   500  2000   300  5500 11000  1200   500  5100   500  2000  1000
## [421]   500    35    30   200   500   150  2000  3000   500   300   500   500
## [433]   800   500   800    50  5000   100  2500  2000   500  1500   500  1500
## [445]   200    30  7600  5500   200  2600    80  1000  4600   200 11000  1500
## [457]  1000   100  1500  1000  6000  8500  1500  8000   350    50    50  1500
## [469]  3000  6500   400   200    50    75   800  1500   300    50   100   100
## [481]   200  6500  2000 10000   500   500   500  5000 10000  2000    50  2100
## [493]   200 11000  1000  7000   600   100  3000   800  9600   200  1000  2500
## [505]  5600    50 12500  6000  5600   100   100    50    30    70    50   800
## [517]    40   800   500  3000 10000    50   250   100  2000  1500   200   100
## [529]   100   100    50   150   100   300   200   500    50  7000  1200   500
## [541]    50  1500  2500  1000  2500    50  2100  4000   500 12000  1500   200
## [553]   500   700   125    30  1500 13000  1000  4800    30    50   300   200
## [565]   200    50   200   900 13000   800  2000  5400  8000  2400  4500   500
## [577]   500    50  2000   300 10000   500    50   800    50 15000  7000  1400
## [589]   200   200    50   200   100    50   200    50   500   100  7000 12000
## [601]  1500  1300   800   800   400    70    50   600    40   800   600  2800
## [613] 10000  2000  9000  5000 10000 10000  3100  6600  9000   100   200   100
## [625]    50   125 16500    50    75  1500   150 11500   500   300  1200  5500
## [637]    50    35  1500   100   500   200    50   500    75   600   100 11000
## [649]  9700   100   100   500   500  2400    30   200    40    50  7000   300
## [661]   400   700   300  1000 10000   400   150  1500    30    75    50  8000
## [673] 13000    50   100  1000  1000   300   300   100   500    70   200   600
## [685]   200   500    70   400 10000 11000 12000   400   300 10000  9000   100
## [697]  1000 16000    35  8000  1500   300   200  1200  1000  1500  1000  3000
## [709] 11000 15000   300  1600  4600    27   300  5900   100  1000    30  2000
## [721]   700   300   300   800   680    50   200  7500  2100 12000    50  3000
## [733]   500  1700  3000   100  3000   200   400 11000  8000   100   400   500
## [745]   600   200   500   800   250   800  1000  2000  1200  1500  9000  1000
## [757]  1100  9500   100   200    30    50    50   300   500    50   200   100
## [769]   800   300  3000  3000    50  7000   100  8000   300    50  5960  7600
## [781]  7600   200   400  3500   500   350  6600
```

```
outliers <- boxplot(birds_by_amass$height, plot=FALSE)$out # save in a vector
```

Which() tells us the rows in which outliers exist. We can store data in a separate variable so we don't lose our original data. We now have a new dataset that excludes outliers on height.

```
new_data_amass<-birds_by_amass
new_data_amass<- new_data_amass[-which(new_data_amass$height %in% outliers),]
```

Sometimes you may want to impute missing values. There are many packages that do this. Hmisc is a powerful package that performs imputation: the two methods are impute() and aregImpute().Impute () imputes missing values using a mean, median or max. aregImpute() is more advanced and uses additive regression, bootstrapping among others to perform imputation. This package assumes that the continuous variables being predicted are linear.

Let's apply it here on our data.

```
if (!require(Hmisc)) {
  install.packages('Hmisc')
  require(Hmisc)
}
```

```
## Loading required package: Hmisc
```

```
##
## Attaching package: 'Hmisc'
```

```
## The following objects are masked from 'package:dplyr':
##
##     src, summarize
```

```
## The following objects are masked from 'package:base':
##
##     format.pval, units
```

One of the common assumptions in imputation is that data are missing at random (MAR). This means that the probability that a missing value depends only on observed variables in the data set and is predicted using those variables using regression. If a data set is large and the number of missing values in the data are small (typically less than 5%), the values can be ignored and analysis can be performed on the rest of the data.Since about half of values are missing for height this is not the recommended approach, but let’s see how you could do it if we had about 5% of values missing for height.

```
impute(birds_by_amass$height, median)
```

```
##      1     2     3     4     5     6     7     8     9    10    11
##      0    0*   200     0    20    50   150   800     0     0     0
##     12    13    14    15    16    17    18    19    20    21    22
##      0  1000    50     0    0*     0     0     0     0     0  5550
##     23    24    25    26    27    28    29    30    31    32    33
##      0     0     0     0     0     0     0     0    0*     0     0
##     34    35    36    37    38    39    40    41    42    43    44
##     0*     0  3566     0     0     0     0    0*    0*     0     0
##     45    46    47    48    49    50    51    52    53    54    55
##      0     0   100    0*     0    0*    0*    0*   700     0     0
##     56    57    58    59    60    61    62    63    64    65    66
##      0     0    0*     0    0*     0    0*     0     0     0     0
##     67    68    69    70    71    72    73    74    75    76    77
##      0  1500     0     0     0     0     0     0     0     0  1500
##     78    79    80    81    82    83    84    85    86    87    88
##      0  5000     0     0     0 11000     0   500  1000 10000     0
##     89    90    91    92    93    94    95    96    97    98    99
##     0*    0*     0     0     0     0     0     0     0    0*     0
##    100   101   102   103   104   105   106   107   108   109   110
##      0     0    0*     0     0     0     0     0     0     0     0
##    111   112   113   114   115   116   117   118   119   120   121
##     0*     0    0*     0    0*    0*     0    0*     0   500     0
##    122   123   124   125   126   127   128   129   130   131   132
##     0*    0*     0     0     0     0     0     0     0    0*     0
##    133   134   135   136   137   138   139   140   141   142   143
##      0    0*    0*    0*    0*    0*    0*     0     0     0     0
##    144   145   146   147   148   149   150   151   152   153   154
##      0    0*    0*    0*   300     0     0     0     0    0*    0*
##    155   156   157   158   159   160   161   162   163   164   165
##      0     0     0     0    0*    0*    0*    0*     0     0     0
##    166   167   168   169   170   171   172   173   174   175   176
##      0     0     0    0*     0    10     0    0*     0     0    0*
##    177   178   179   180   181   182   183   184   185   186   187
##      0     0     0   200     0     0    0*     0    0*     0     0
##    188   189   190   191   192   193   194   195   196   197   198
##     0*     0     0    75    0*    0*   100     0     0     0     0
##    199   200   201   202   203   204   205   206   207   208   209
##      0    10     0     0     0     0     0    0*   200    0*   300
##    210   211   212   213   214   215   216   217   218   219   220
##      0    0*     0    0*    0*    0*    0*     0     0     0     0
##    221   222   223   224   225   226   227   228   229   230   231
##      0  8000  3000   300     0     0   100     0     0     0  1500
##    232   233   234   235   236   237   238   239   240   241   242
##     0*     0     0     0   300    0*     0     0    0*   100   150
##    243   244   245   246   247   248   249   250   251   252   253
##      0     0   100   100 13000     0    0*     0     0    0*     0
##    254   255   256   257   258   259   260   261   262   263   264
##    100     0    0*    0*     0     0    10     0     0     0     0
##    265   266   267   268   269   270   271   272   273   274   275
##      0     0    0*    0*     0     0     0     0     0    0*     0
##    276   277   278   279   280   281   282   283   284   285   286
##     0*    0*    10    0*    10     0  1000     0    0*     0     0
##    287    288    289    290    291    292    293    294    295    296    297
##      0      0     0*    100      0      0     0*      0      0      0      0
##    298    299    300    301    302    303    304    305    306    307    308
##      0     50      0      0      0      0      0     0*      0    200      0
##    309    310    311    312    313    314    315    316    317    318    319
##      0      0     0*   4000      0      0      0      0     0*      0      0
##    320    321    322    323    324    325    326    327    328    329    330
##      0      0      0      0      0      0      0      0      0     0*      0
##    331    332    333    334    335    336    337    338    339    340    341
##      0      0      0      0      0      0      0     0*      0     50      0
##    342    343    344    345    346    347    348    349    350    351    352
##      0      0     10     0*    500     10      0    500      0      0      0
##    353    354    355    356    357    358    359    360    361    362    363
##      0      0      0    200   1200      0      0      0      0      0      0
##    364    365    366    367    368    369    370    371    372    373    374
##   1500     20      0      0      0    500      0      0      0      0      0
##    375    376    377    378    379    380    381    382    383    384    385
##      0      0      0      0    200      0   1500      0    600      0     0*
##    386    387    388    389    390    391    392    393    394    395    396
##      0      0      0      0      0     0*      0     0*   9500      0     0*
##    397    398    399    400    401    402    403    404    405    406    407
##      0      0      0      0     0*      0      0   2000      0      0      0
##    408    409    410    411    412    413    414    415    416    417    418
##      0      0   1000      0     0*      0      0      0     0*      0      0
##    419    420    421    422    423    424    425    426    427    428    429
##      0      0      0      0      0      0      0     0*      0     0*   1000
##    430    431    432    433    434    435    436    437    438    439    440
##      0     0*     0*   3000     0*   1000      0      0   1000     10   2000
##    441    442    443    444    445    446    447    448    449    450    451
##   1500     50      0      0      0      0      0      0     0*      0      0
##    452    453    454    455    456    457    458    459    460    461    462
##      0    100      0      0      0     0*   7000     0*      0      0     0*
##    463    464    465    466    467    468    469    470    471    472    473
##     0*      0      0      0      0      0      0      0      0      0      0
##    474    475    476    477    478    479    480    481    482    483    484
##      0      0      0      0      0      0      0      0      0      0      0
##    485    486    487    488    489    490    491    492    493    494    495
##      0      0      0      0     0*      0      0      0      0    300     50
##    496    497    498    499    500    501    502    503    504    505    506
##      0      0      0      0      0      0      0     0*      0      0      0
##    507    508    509    510    511    512    513    514    515    516    517
##     0*     0*      0      0      0      0      0      0      0     0*     0*
##    518    519    520    521    522    523    524    525    526    527    528
##      0     0*      0      0      0      0     0*      0      0      0      0
##    529    530    531    532    533    534    535    536    537    538    539
##   1000      0      0   5600      0      0      0     0*     0*     0*      0
##    540    541    542    543    544    545    546    547    548    549    550
##      0     0*     0*      0     0*   6000      0     0*     0*     0*      0
##    551    552    553    554    555    556    557    558    559    560    561
##      0      0      0      0      0   4000      0     0*   1200     50     0*
##    562    563    564    565    566    567    568    569    570    571    572
##     0*      0     0*      0      0      0   2500    200     0*     10     0*
##    573    574    575    576    577    578    579    580    581    582    583
##      0      0      0      0     50   4000      0      0  10800    100     0*
##    584    585    586    587    588    589    590    591    592    593    594
##     0*   6000     0*     0*      0     0*      0      0     20      0      0
##    595    596    597    598    599    600    601    602    603    604    605
##      0   2500      0      0      0    500   7500      0      0      0   4000
##    606    607    608    609    610    611    612    613    614    615    616
##  12000   7000      0      0     50     0*     0*   7000      0     0*   2000
##    617    618    619    620    621    622    623    624    625    626    627
##   1700     0*      0      0      0     0*      0   9000      0      0      0
##    628    629    630    631    632    633    634    635    636    637    638
##     0*     0*      0      0      0     0*      0      0      0     0*   1700
##    639    640    641    642    643    644    645    646    647    648    649
##     0*      0      0      0      0      0      0      0   2100      0      0
##    650    651    652    653    654    655    656    657    658    659    660
##     0*   7500      0     0*      0    100     0*     0*      0      0     0*
##    661    662    663    664    665    666    667    668    669    670    671
##      0     0*     0*     0*     0*      0      0     0*      0      0      0
##    672    673    674    675    676    677    678    679    680    681    682
##      0     10      0      0     0*      0      0     10     0*     10      0
##    683    684    685    686    687    688    689    690    691    692    693
##      0      0     0*      0     0*      0     0*      0     10      0     10
##    694    695    696    697    698    699    700    701    702    703    704
##      0     0*      0      0      0    100     0*      0     0*     0*      0
##    705    706    707    708    709    710    711    712    713    714    715
##      0      0     0*     0*     0*      0      0   7000      0      0     0*
##    716    717    718    719    720    721    722    723    724    725    726
##      0      0      0      0     10     0*      0      0      0      0      0
##    727    728    729    730    731    732    733    734    735    736    737
##      0      0      0     0*      0      0     0*   1000     0*      0   2000
##    738    739    740    741    742    743    744    745    746    747    748
##      0      0      0      0     0*     0*      0      0      0      0      0
##    749    750    751    752    753    754    755    756    757    758    759
##      0   1500      0     0*      0      0    400    200     0*     0*     0*
##    760    761    762    763    764    765    766    767    768    769    770
##     0*      0     0*   5000   9000      0      0      0     20     0*      0
##    771    772    773    774    775    776    777    778    779    780    781
##      0     0*     0*    200     75    100    300      0     0*     0*      0
##    782    783    784    785    786    787    788    789    790    791    792
##     0*   1200     0*      0     0*     0*      0     0*      0     0*     0*
##    793    794    795    796    797    798    799    800    801    802    803
##    600   1000     0*      0     0*      0     0*      0     0*      0      0
##    804    805    806    807    808    809    810    811    812    813    814
##      0      0      0      0      0      0   7500      0     0*      0      0
##    815    816    817    818    819    820    821    822    823    824    825
##     0*  11000   1643      0     0*   8000     0*      0  14000     35     0*
##    826    827    828    829    830    831    832    833    834    835    836
##      0     0*    300     0*      0    800     0*      0     0*     0*  10000
##    837    838    839    840    841    842    843    844    845    846    847
##      0   1500      0     0*      0      0     0*      0     0*     0*      0
##    848    849    850    851    852    853    854    855    856    857    858
##     0*     0*      0      0     0*      0      0   3200     0*      0      0
##    859    860    861    862    863    864    865    866    867    868    869
##      0      0      0      0      0      0      0      0      0      0      0
##    870    871    872    873    874    875    876    877    878    879    880
##      0     10      0     0*      0      0      0      0     0*      0      0
##    881    882    883    884    885    886    887    888    889    890    891
##    100      0   1000      0      0     0*      0      0      0      0      0
##    892    893    894    895    896    897    898    899    900    901    902
##      0      0     10      0      0      0   1570      1     0*      5     0*
##    903    904    905    906    907    908    909    910    911    912    913
##      0    500      0      0      5      0     0*      0   1000      0      0
##    914    915    916    917    918    919    920    921    922    923    924
##     0*   1500      0      0      0   1500    500      0      0      0      0
##    925    926    927    928    929    930    931    932    933    934    935
##     0*      0     0*      0      0      0     0*     0*     0*      0      0
##    936    937    938    939    940    941    942    943    944    945    946
##     0*     0*     0*    600      0      0      0    100     0*      0      0
##    947    948    949    950    951    952    953    954    955    956    957
##     0*      0      0      0    100      0    500      0      0     0*      0
##    958    959    960    961    962    963    964    965    966    967    968
##      0      0     0*      0      0     25     0*     0*     0*     0*   9000
##    969    970    971    972    973    974    975    976    977    978    979
##      0      0      0      0    100      0     0*     0*      0      0     10
##    980    981    982    983    984    985    986    987    988    989    990
##      0     0*     0*      0   9000    100      0      0    700     0*      0
##    991    992    993    994    995    996    997    998    999   1000   1001
##      5     0*     0*      0      0      0      0   1000      0      0     0*
##   1002   1003   1004   1005   1006   1007   1008   1009   1010   1011   1012
##      0      0      0      0      0     0*      0     0*     0*      0      0
##   1013   1014   1015   1016   1017   1018   1019   1020   1021   1022   1023
##    600     0*   3000   7500      0      0     50     0*     0*      0      0
##   1024   1025   1026   1027   1028   1029   1030   1031   1032   1033   1034
##     0*     0*   3000  10000      0      0     50      0      0    100      0
##   1035   1036   1037   1038   1039   1040   1041   1042   1043   1044   1045
##      0      0      0     0*      0     20   7000      0      0      0      0
##   1046   1047   1048   1049   1050   1051   1052   1053   1054   1055   1056
##      0     0*      0      0   4000      0     0*     0*     0*      0      0
##   1057   1058   1059   1060   1061   1062   1063   1064   1065   1066   1067
##     0*     0*     0*      0     0*      0     0*     0*     15     0*     0*
##   1068   1069   1070   1071   1072   1073   1074   1075   1076   1077   1078
##     0*     0*     0*     0*     0*   1000     0*      0     0*     0*      0
##   1079   1080   1081   1082   1083   1084   1085   1086   1087   1088   1089
##     10     0*      0      0      0      0      0     0*   5800     0*     0*
##   1090   1091   1092   1093   1094   1095   1096   1097   1098   1099   1100
##     0*     0*     0*     0*      0    100    200     0*    500      0      0
##   1101   1102   1103   1104   1105   1106   1107   1108   1109   1110   1111
##      0      0     0*      0      0      0      0     0*      0     0*      0
##   1112   1113   1114   1115   1116   1117   1118   1119   1120   1121   1122
##     0*     0*     0*     0*      0      0     0*      0   1174     0*     0*
##   1123   1124   1125   1126   1127   1128   1129   1130   1131   1132   1133
##     0*      0      0      0      0      0      0      0      0     0*      0
##   1134   1135   1136   1137   1138   1139   1140   1141   1142   1143   1144
##      0     0*      0      0     0*   8500     0*      0      0      0     0*
##   1145   1146   1147   1148   1149   1150   1151   1152   1153   1154   1155 
##      0      0     0*     0*      0     0*      0   1000      0     0*     0* 
##   1156   1157   1158   1159   1160   1161   1162   1163   1164   1165   1166 
##     0*      0      0      0      0     0*     0*     50     0*     0*    500 
##   1167   1168   1169   1170   1171   1172   1173   1174   1175   1176   1177 
##     0*      0      0      0      0      0      0      0     0*     0*      0 
##   1178   1179   1180   1181   1182   1183   1184   1185   1186   1187   1188 
##   2000      0     0*      0      0   5000      0      0      0     0*      0 
##   1189   1190   1191   1192   1193   1194   1195   1196   1197   1198   1199 
##      0   1100      0     10      0      0      0      0   1000    100     50 
##   1200   1201   1202   1203   1204   1205   1206   1207   1208   1209   1210 
##      0     0*      0    200      0     50      0   2000     0*     0*      0 
##   1211   1212   1213   1214   1215   1216   1217   1218   1219   1220   1221 
##      0      0      0    300    400      0    200      0     0*      0   1000 
##   1222   1223   1224   1225   1226   1227   1228   1229   1230   1231   1232 
##      0     15      0   2000      0      0      5      0      0   2000    300 
##   1233   1234   1235   1236   1237   1238   1239   1240   1241   1242   1243 
##      0      0    600    300    400      0      0  11000     0*      0      0 
##   1244   1245   1246   1247   1248   1249   1250   1251   1252   1253   1254 
##     10      0      0      0      0     0*      0      0     0*      0      0 
##   1255   1256   1257   1258   1259   1260   1261   1262   1263   1264   1265 
##      0      0      0   7000    500     10    500     10      0      0     0* 
##   1266   1267   1268   1269   1270   1271   1272   1273   1274   1275   1276 
##      0   1500     10   1500     10     0*   7000      0      0   2000     0* 
##   1277   1278   1279   1280   1281   1282   1283   1284   1285   1286   1287 
##   3000      0      0      0     0*     0*      0     0*      0      0      0 
##   1288   1289   1290   1291   1292   1293   1294   1295   1296   1297   1298 
##      0      0      0      0   1000   2000      0      0     0*     0*    500 
##   1299   1300   1301   1302   1303   1304   1305   1306   1307   1308   1309 
##      0    800      0      0     0*      0    100      0   1500      0      0 
##   1310   1311   1312   1313   1314   1315   1316   1317   1318   1319   1320 
##     75      0     0*      0      0     10      0      5      0      0      0 
##   1321   1322   1323   1324   1325   1326   1327   1328   1329   1330   1331 
##     20      0    500     0*      0     0*      0     0*     0*     0*      0 
##   1332   1333   1334   1335   1336   1337   1338   1339   1340   1341   1342 
##      0     50      0     0*      0      0   1100     10      0      0     50 
##   1343   1344   1345   1346   1347   1348   1349   1350   1351   1352   1353 
##   4000     0*      0   5400     0*      0      0   2000      0    100      0 
##   1354   1355   1356   1357   1358   1359   1360   1361   1362   1363   1364 
##    100     0*     0*     0*     0*      0   1000      0      0     0*      0 
##   1365   1366   1367   1368   1369   1370   1371   1372   1373   1374   1375 
##      0      0      0     0*     50      0      0      0     0*    800      0 
##   1376   1377   1378   1379   1380   1381   1382   1383   1384   1385   1386 
##     0*      0     0*     0*      0     50     15      0     0*      0     0* 
##   1387   1388   1389   1390   1391   1392   1393   1394   1395   1396   1397 
##    400     0*  10000    900      0      0    100      0     0*     10     0* 
##   1398   1399   1400   1401   1402   1403   1404   1405   1406   1407   1408 
##    150     0*      0    330     0*    100      0      0     50      0      0 
##   1409   1410   1411   1412   1413   1414   1415   1416   1417   1418   1419 
##     0*     75      0      0     30      0      0      0     0*     50   4000 
##   1420   1421   1422   1423   1424   1425   1426   1427   1428   1429   1430 
##     0*      0    500      0      0    500    100    100     0*      0     10 
##   1431   1432   1433   1434   1435   1436   1437   1438   1439   1440   1441 
##   1600      0    400     0*      0      0     30   5400     0*      0      0 
##   1442   1443   1444   1445   1446   1447   1448   1449   1450   1451   1452 
##     0*    100      0     50      0     0*      0      0      0      0   4600 
##   1453   1454   1455   1456   1457   1458   1459   1460   1461   1462   1463 
##   1500   9000      0      0      0      0  12500    150     25      0   2000 
##   1464   1465   1466   1467   1468   1469   1470   1471   1472   1473   1474 
##      0   2000      0      0    400   8000     10      0     0*     50     0* 
##   1475   1476   1477   1478   1479   1480   1481   1482   1483   1484   1485 
##     0*      0      0     0*      0      0    100      0      0      0      0 
##   1486   1487   1488   1489   1490   1491   1492   1493   1494   1495   1496 
##    200      0      0      0      0      0     0*   2600     0*      0      0 
##   1497   1498   1499   1500   1501   1502   1503   1504   1505   1506   1507 
##     0*      0      0      0   5000      0      0      0     0*      0      0 
##   1508   1509   1510   1511   1512   1513   1514   1515   1516   1517   1518 
##      0      5     0*      0      0      0      0      0    300      0      0 
##   1519   1520   1521   1522   1523   1524   1525   1526   1527   1528   1529 
##     0*      0      0      0      0     0*      0      0      0      0      0 
##   1530   1531   1532   1533   1534   1535   1536   1537   1538   1539   1540 
##      0      0      0      0     0*      0     10      0      0      0      0 
##   1541   1542   1543   1544   1545   1546   1547   1548   1549   1550   1551 
##      0    800      0      0      0     0*     0*      0   1000     70    400 
##   1552   1553   1554   1555   1556   1557   1558   1559   1560   1561   1562 
##     0*    200      0    100      0      0      0     0*      0      0      5 
##   1563   1564   1565   1566   1567   1568   1569   1570   1571   1572   1573 
##      0      0      0     20    100      0      0      0      0   3000      0 
##   1574   1575   1576   1577   1578   1579   1580   1581   1582   1583   1584 
##    100      0     0*     0*      0   3500   7000     30     0*     0*      0 
##   1585   1586   1587   1588   1589   1590   1591   1592   1593   1594   1595 
##     0*      0    500      0     10    500      0      0     0*      0      0 
##   1596   1597   1598   1599   1600   1601   1602   1603   1604   1605   1606 
##      0      5      0     10      0      0      0  10000    500      0      0 
##   1607   1608   1609   1610   1611   1612   1613   1614   1615   1616   1617 
##     0*      0      0    400      0    200     0*      0     0*     0*     0* 
##   1618   1619   1620   1621   1622   1623   1624   1625   1626   1627   1628 
##     0*      0      0     0*      0      0      0      0     80     0*      0 
##   1629   1630   1631   1632   1633   1634   1635   1636   1637   1638   1639 
##    100     0*      0      0      0   6000     30   4000    100  12000   1000 
##   1640   1641   1642   1643   1644   1645   1646   1647   1648   1649   1650 
##    400   1000      0     0*      0    100   1000      0    900      0     20 
##   1651   1652   1653   1654   1655   1656   1657   1658   1659   1660   1661 
##     20     35   4650     10     0*   1400  13000   6500     50      0      0 
##   1662   1663   1664   1665   1666   1667   1668   1669   1670   1671   1672 
##      0      0      0     50    700     0*      0   5500      2      0      0 
##   1673   1674   1675   1676   1677   1678   1679   1680   1681   1682   1683 
##      0      0     10      0      0      0      0   1000      0      0      0 
##   1684   1685   1686   1687   1688   1689   1690   1691   1692   1693   1694 
##      0      0      0      0      0     10      0      0      0      0      0 
##   1695   1696   1697   1698   1699   1700   1701   1702   1703   1704   1705 
##      0      0      0      0      0      0      0      0      0      0      0 
##   1706   1707   1708   1709   1710   1711   1712   1713   1714   1715   1716 
##      0      0      0      0      0      0      0     0*      0      0      0 
##  1717  1718  1719  1720  1721  1722  1723  1724  1725  1726  1727 
##     0     0    0*     0     0     5  6000     0     0     0     0 
##  1728  1729  1730  1731  1732  1733  1734  1735  1736  1737  1738 
##    0*    0*     0     0     0    20     0     0     0     0     0 
##  1739  1740  1741  1742  1743  1744  1745  1746  1747  1748  1749 
##     0     0     0    0*   500     0     0     0     0     0     0 
##  1750  1751  1752  1753  1754  1755  1756  1757  1758  1759  1760 
##    0*     0   300     0     0  7000     0     0     0    0*  3000 
##  1761  1762  1763  1764  1765  1766  1767  1768  1769  1770  1771 
##    0*     0     0  1000     0     0     0   100     0   200   500 
##  1772  1773  1774  1775  1776  1777  1778  1779  1780  1781  1782 
##     0     0    0*     0     0   600    0*    15  1000   100   500 
##  1783  1784  1785  1786  1787  1788  1789  1790  1791  1792  1793 
##   700    0*   100   600    0*    0*  1500   500     0    50   200 
##  1794  1795  1796  1797  1798  1799  1800  1801  1802  1803  1804 
##     0   100     0     0  6000  1000     0    0*     0     0     0 
##  1805  1806  1807  1808  1809  1810  1811  1812  1813  1814  1815 
##     0     0     0     0    0*   350     0     0     0 11000     0 
##  1816  1817  1818  1819  1820  1821  1822  1823  1824  1825  1826 
##    10     0   300  2500 10000     0     0     0  8600  3000    0* 
##  1827  1828  1829  1830  1831  1832  1833  1834  1835  1836  1837 
##   200     0    0*    50     0  1200     0  1000     0   100     0 
##  1838  1839  1840  1841  1842  1843  1844  1845  1846  1847  1848 
## 10000  2000   200    0*     0     0   200  5500     0     0    0* 
##  1849  1850  1851  1852  1853  1854  1855  1856  1857  1858  1859 
##   100  7800    20     0     0     0     0    50    10     0     0 
##  1860  1861  1862  1863  1864  1865  1866  1867  1868  1869  1870 
##     0     0     0     5    25    50     0     0    10    30    0* 
##  1871  1872  1873  1874  1875  1876  1877  1878  1879  1880  1881 
##     0     0    10     0     0     0     0     0     0     0     0 
##  1882  1883  1884  1885  1886  1887  1888  1889  1890  1891  1892 
##     0  1000     0     0     0     0     0    0*     0     0     0 
##  1893  1894  1895  1896  1897  1898  1899  1900  1901  1902  1903 
##   250    0*    0*     0     0     0    0*   200    10    0*    10 
##  1904  1905  1906  1907  1908  1909  1910  1911  1912  1913  1914 
##     0     0    0*     0     0     0   100    10    10    0*   200 
##  1915  1916  1917  1918  1919  1920  1921  1922  1923  1924  1925 
##    0*     0     5     0     0     0   100     0     0     0     0 
##  1926  1927  1928  1929  1930  1931  1932  1933  1934  1935  1936 
##  2100     0     0     0     0     0     0     0     0    0*   800 
##  1937  1938  1939  1940  1941  1942  1943  1944  1945  1946  1947 
##     0     0   500   500   200     0  1500     0     0   200    0* 
##  1948  1949  1950  1951  1952  1953  1954  1955  1956  1957  1958 
##     0     0     0     0     0    0*    50    0*     0    0*  1000 
##  1959  1960  1961  1962  1963  1964  1965  1966  1967  1968  1969 
## 10200     0    0*  1000     0    0*    0*  7000   800     0  1000 
##  1970  1971  1972  1973  1974  1975  1976  1977  1978  1979  1980 
##    25     0     0    20     0     5     0     0     0     0  5000 
##  1981  1982  1983  1984  1985  1986  1987  1988  1989  1990  1991 
##  5000 10000     0  1000 11000     5   300   700     0   200     0 
##  1992  1993  1994  1995  1996  1997  1998  1999  2000  2001  2002 
##     0  6700     0  8000     0     0     0     0     0   700    10 
##   2003   2004   2005   2006   2007   2008   2009   2010   2011   2012   2013 
##     10      5     50      0      0     10      0     50      0      0      0 
##   2014   2015   2016   2017   2018   2019   2020   2021   2022   2023   2024 
##    100     75      0      0      0      0      0      0      0     50      0 
##   2025   2026   2027   2028   2029   2030   2031   2032   2033   2034   2035 
##     0*      0      0      0      0      0     0*      0    200      0      0 
##   2036   2037   2038   2039   2040   2041   2042   2043   2044   2045   2046 
##    200      0      0     0*   1000      0     50      0     0*      0      0 
##   2047   2048   2049   2050   2051   2052   2053   2054   2055   2056   2057 
##      0      0      0      0    100      0    700    200     0*      0      0 
##   2058   2059   2060   2061   2062   2063   2064   2065   2066   2067   2068 
##      0   1200      0    500     0*     0*      0      0     10   1500      5 
##   2069   2070   2071   2072   2073   2074   2075   2076   2077   2078   2079 
##     0*   1900    800      0      0     0*      0    400     0*   1000      0 
##   2080   2081   2082   2083   2084   2085   2086   2087   2088   2089   2090 
##    400      0     50     60      0      0     0*      0      0    200    800 
##   2091   2092   2093   2094   2095   2096   2097   2098   2099   2100   2101 
##      0      0      0   1000     0*    700      0     0*     75    150     50 
##   2102   2103   2104   2105   2106   2107   2108   2109   2110   2111   2112 
##      0      0      0      0    500      0    100      0      0     50     0* 
##   2113   2114   2115   2116   2117   2118   2119   2120   2121   2122   2123 
##      0      0      0      0      0      5      0      0     0*      0      0 
##   2124   2125   2126   2127   2128   2129   2130   2131   2132   2133   2134 
##      0     50      0      0      0    300     0*    400    150    200      0 
##   2135   2136   2137   2138   2139   2140   2141   2142   2143   2144   2145 
##    200    100      0      0      0     25     20     0*     0*   3000   3000 
##   2146   2147   2148   2149   2150   2151   2152   2153   2154   2155   2156 
##      0   2000   1200      0     0*      0      0     0*     30     10      0 
##   2157   2158   2159   2160   2161   2162   2163   2164   2165   2166   2167 
##   6100      0      0   1500      0      0      0      0    100      0     10 
##   2168   2169   2170   2171   2172   2173   2174   2175   2176   2177   2178 
##      0     50     50      0    500      0   2000    300      0     0*   5500 
##   2179   2180   2181   2182   2183   2184   2185   2186   2187   2188   2189 
##     0*  11000   1200    500     0*      0      0      0      0      0      0 
##   2190   2191   2192   2193   2194   2195   2196   2197   2198   2199   2200 
##   5100      0    500   2000   1000     0*      0    500      0     10      0 
##   2201   2202   2203   2204   2205   2206   2207   2208   2209   2210   2211 
##      0      0      0     35      0      0      0      0      0      0      0 
##   2212   2213   2214   2215   2216   2217   2218   2219   2220   2221   2222 
##      0      0     30      0     0*      0      0      0      0      0    200 
##   2223   2224   2225   2226   2227   2228   2229   2230   2231   2232   2233 
##     20      0      0      0      0      0      0      0      0      0     0* 
##   2234   2235   2236   2237   2238   2239   2240   2241   2242   2243   2244 
##      0      0      0      0      0      0     0*      0    500    150     20 
##   2245   2246   2247   2248   2249   2250   2251   2252   2253   2254   2255 
##     0*      0   2000      0      0   3000    500      0    300     0*    500 
##   2256   2257   2258   2259   2260   2261   2262   2263   2264   2265   2266 
##    500      0      0    800    500      0    800     0*     0*      0      0 
##   2267   2268   2269   2270   2271   2272   2273   2274   2275   2276   2277 
##      0      0      0     50     0*   5000     0*    100      0      0   2500 
##   2278   2279   2280   2281   2282   2283   2284   2285   2286   2287   2288 
##     10   2000      0    500   1500      0    500   1500      0      0     0* 
##   2289   2290   2291   2292   2293   2294   2295   2296   2297   2298   2299 
##     0*     0*      0     0*      0    200      0      0     30     0*   7600 
##   2300   2301   2302   2303   2304   2305   2306   2307   2308   2309   2310 
##   5500    200      0      0      0     10   2600      0     80   1000   4600 
##   2311   2312   2313   2314   2315   2316   2317   2318   2319   2320   2321 
##      0     10      0      0      0     25      5      0    200      0      0 
##   2322   2323   2324   2325   2326   2327   2328   2329   2330   2331   2332 
##      0  11000      0   1500      0   1000    100     10     0*      0   1500 
##   2333   2334   2335   2336   2337   2338   2339   2340   2341   2342   2343 
##   1000     20   6000   8500   1500      0      0     0*   8000    350      0 
##   2344   2345   2346   2347   2348   2349   2350   2351   2352   2353   2354 
##      0     50      0     50   1500      0      0     10      0     0*   3000 
##   2355   2356   2357   2358   2359   2360   2361   2362   2363   2364   2365 
##      0      0      0      0      0      0      0     10      0      0      0 
##   2366   2367   2368   2369   2370   2371   2372   2373   2374   2375   2376 
##   6500     20      0      0      0      0      0      0    400     0*      0 
##   2377   2378   2379   2380   2381   2382   2383   2384   2385   2386   2387 
##      0     0*      0      0      0    200     50      0      0      0      0 
##   2388   2389   2390   2391   2392   2393   2394   2395   2396   2397   2398 
##      0      0      0     75    800      0      0      0      0   1500      0 
##   2399   2400   2401   2402   2403   2404   2405   2406   2407   2408   2409 
##     0*     0*      0      0    300     0*      0      0      0      5      0 
##   2410   2411   2412   2413   2414   2415   2416   2417   2418   2419   2420 
##      0      0     50      0     0*      0      0      0      0    100      0 
##   2421   2422   2423   2424   2425   2426   2427   2428   2429   2430   2431 
##      1      0      0     0*      0      0     10      0    100    200      0 
##   2432   2433   2434   2435   2436   2437   2438   2439   2440   2441   2442 
##     0*      0      0   6500      0      0   2000      0  10000      5    500 
##   2443   2444   2445   2446   2447   2448   2449   2450   2451   2452   2453 
##      0     0*    500      0     0*      0    500      0      0   5000      0 
##   2454   2455   2456   2457   2458   2459   2460   2461   2462   2463   2464 
##  10000      0     0*   2000      0      0      0      0      0      0     50 
##   2465   2466   2467   2468   2469   2470   2471   2472   2473   2474   2475 
##     20   2100     10      0      0    200      0      0      0      0      0 
##   2476   2477   2478   2479   2480   2481   2482   2483   2484   2485   2486 
##  11000      0   1000      0   7000     0*      0      0    600    100      0 
##   2487   2488   2489   2490   2491   2492   2493   2494   2495   2496   2497 
##      0   3000      0      0      0      0    800      0      0      0      0 
##   2498   2499   2500   2501   2502   2503   2504   2505   2506   2507   2508 
##      0      0      0     0*   9600      0      0      0      0      0     0* 
##   2509   2510   2511   2512   2513   2514   2515   2516   2517   2518   2519 
##      0    200     0*   1000   2500   5600      0      0      0     0*      0 
##   2520   2521   2522   2523   2524   2525   2526   2527   2528   2529   2530 
##      1     0*      0      0     50  12500   6000      0      0      0      0 
##   2531   2532   2533   2534   2535   2536   2537   2538   2539   2540   2541 
##      0      0     0*   5600      0      0      0      0      0      0      0 
##   2542   2543   2544   2545   2546   2547   2548   2549   2550   2551   2552 
##      0      0      0     10      0    100      0    100      0     0*     50 
##   2553   2554   2555   2556   2557   2558   2559   2560   2561   2562   2563 
##      0      0      0      0      0     30     70     50      0      0      0 
##   2564   2565   2566   2567   2568   2569   2570   2571   2572   2573   2574 
##      0      0      0    800      0      0      0     10      0      0      0 
##   2575   2576   2577   2578   2579   2580   2581   2582   2583   2584   2585
##      0      0      0      0      0      0      0     0*      0      0      0
##   2586   2587   2588   2589   2590   2591   2592   2593   2594   2595   2596
##     40     10    800      0      0    500   3000      0      0      0  10000
##   2597   2598   2599   2600   2601   2602   2603   2604   2605   2606   2607
##      0      0      0     0*      0     50    250    100      0      0   2000
##   2608   2609   2610   2611   2612   2613   2614   2615   2616   2617   2618
##      0     20     10      0     0*      0      0      0      0   1500     0*
##   2619   2620   2621   2622   2623   2624   2625   2626   2627   2628   2629
##      0      0      0      0     0*    200      0    100      0    100      0
##   2630   2631   2632   2633   2634   2635   2636   2637   2638   2639   2640
##      0      0      0      0      0      0     0*      0      0      0      0
##   2641   2642   2643   2644   2645   2646   2647   2648   2649   2650   2651
##     0*     0*      0     20     10      0      0      0      0      0      0
##   2652   2653   2654   2655   2656   2657   2658   2659   2660   2661   2662
##      0      0      0      0    100      0     0*      0      0      0      0
##   2663   2664   2665   2666   2667   2668   2669   2670   2671   2672   2673
##     0*     0*      0     0*     50      0     0*    150    100    300    200
##   2674   2675   2676   2677   2678   2679   2680   2681   2682   2683   2684
##    500      5     0*      0     0*      0      0      0      0     50     0*
##   2685   2686   2687   2688   2689   2690   2691   2692   2693   2694   2695
##      0      0   7000      0   1200    500      0     50      0   1500      0
##   2696   2697   2698   2699   2700   2701   2702   2703   2704   2705   2706
##     0*     0*      0   2500      0      0   1000     0*     0*     0*      0
##   2707   2708   2709   2710   2711   2712   2713   2714   2715   2716   2717
##   2500      0     15      0     50      0   2100      0      0     0*      0
##   2718   2719   2720   2721   2722   2723   2724   2725   2726   2727   2728
##      0      0      0     0*   4000    500      0  12000   1500    200      0
##   2729   2730   2731   2732   2733   2734   2735   2736   2737   2738   2739
##      0      0      0      0      0      0      0      0      0      0      0
##   2740   2741   2742   2743   2744   2745   2746   2747   2748   2749   2750
##     20      0     0*      0     0*      0      0     0*      0      0    500
##   2751   2752   2753   2754   2755   2756   2757   2758   2759   2760   2761
##      0      0      0      0    700     0*      0      0      0      0     0*
##   2762   2763   2764   2765   2766   2767   2768   2769   2770   2771   2772
##      0      0      0    125     0*      0      0     0*      0      0      0
##   2773   2774   2775   2776   2777   2778   2779   2780   2781   2782   2783
##      0      0      0      0     30      0     0*      0      0      0   1500
##   2784   2785   2786   2787   2788   2789   2790   2791   2792   2793   2794
##  13000      0      0      0      0      0      0      0   1000     0*     0*
##   2795   2796   2797   2798   2799   2800   2801   2802   2803   2804   2805
##      0      0   4800     0*     30      0     0*     50     10      0    300
##   2806   2807   2808   2809   2810   2811   2812   2813   2814   2815   2816
##    200      0      0      0      0    200      0     50      0    200     0*
##   2817   2818   2819   2820   2821   2822   2823   2824   2825   2826   2827
##      0      0    900      0      0      0      0      0  13000     0*    800
##   2828   2829   2830   2831   2832   2833   2834   2835   2836   2837   2838
##      0      0     0*     0*   2000      0      0      0      0      0   5400
##   2839   2840   2841   2842   2843   2844   2845   2846   2847   2848   2849
##   8000     10     0*   2400      0      0      0      0      0   4500      0
##   2850   2851   2852   2853   2854   2855   2856   2857   2858   2859   2860
##      0      0    500      0    500      0     50   2000    300      0  10000
##   2861   2862   2863   2864   2865   2866   2867   2868   2869   2870   2871 
##    500     0*     0*     50      0      0      0      0     0*      0      0 
##   2872   2873   2874   2875   2876   2877   2878   2879   2880   2881   2882 
##      0    800     50  15000      0   7000      0      0      0      0   1400 
##   2883   2884   2885   2886   2887   2888   2889   2890   2891   2892   2893 
##      0     0*      0      0    200      0     0*     0*      0     0*      0 
##   2894   2895   2896   2897   2898   2899   2900   2901   2902   2903   2904 
##     0*      0      0      0      0     20      0      0      0      0      0 
##   2905   2906   2907   2908   2909   2910   2911   2912   2913   2914   2915 
##      0      0      0      0     15      0      0      0     10      0    200 
##   2916   2917   2918   2919   2920   2921   2922   2923   2924   2925   2926 
##      0      0     0*      0      0      0      0      0     50    200      0 
##   2927   2928   2929   2930   2931   2932   2933   2934   2935   2936   2937 
##      0      0      0      0      0    100     50    200      0      0      0 
##   2938   2939   2940   2941   2942   2943   2944   2945   2946   2947   2948 
##      0      0      0     50    500      0    100      0      0      0   7000 
##   2949   2950   2951   2952   2953   2954   2955   2956   2957   2958   2959 
##     10      0      0      0     0*  12000     0*   1500      0   1300      0 
##   2960   2961   2962   2963   2964   2965   2966   2967   2968   2969   2970 
##    800      0     0*      0      0      0    800      0    400      0      0 
##   2971   2972   2973   2974   2975   2976   2977   2978   2979   2980   2981 
##     0*      0      0     0*      0      0      0      0     0*     0*     0* 
##   2982   2983   2984   2985   2986   2987   2988   2989   2990   2991   2992 
##      0     0*      0     0*      0      0      0      0     70     0*     0* 
##   2993   2994   2995   2996   2997   2998   2999   3000   3001   3002   3003 
##      0      0      0      0     0*     0*     50     0*     0*     0*     0* 
##   3004   3005   3006   3007   3008   3009   3010   3011   3012   3013   3014 
##     0*     0*    600      0      0      0     40     0*    800      0    600 
##   3015   3016   3017   3018   3019   3020   3021   3022   3023   3024   3025 
##     0*      0   2800      0     0*      0      0      0      0  10000   2000 
##   3026   3027   3028   3029   3030   3031   3032   3033   3034   3035   3036 
##      0   9000      0     0*      0   5000      0  10000      0      0  10000 
##   3037   3038   3039   3040   3041   3042   3043   3044   3045   3046   3047 
##     0*     0*      0      0      0     0*      0     0*      0      0      0 
##   3048   3049   3050   3051   3052   3053   3054   3055   3056   3057   3058 
##     0*      0   3100      0     0*   6600   9000    100    200    100     0* 
##   3059   3060   3061   3062   3063   3064   3065   3066   3067   3068   3069 
##      0     50      0     0*      0      0     0*      0     10      0      0 
##   3070   3071   3072   3073   3074   3075   3076   3077   3078   3079   3080 
##      0      0      0    125      0      0      0      0      0      0  16500 
##   3081   3082   3083   3084   3085   3086   3087   3088   3089   3090   3091 
##      0     0*     50      0      0      0      0      0      0      0      0 
##   3092   3093   3094   3095   3096   3097   3098   3099   3100   3101   3102 
##      0     0*      0     75      0     0*      0      0      0      0      0 
##   3103   3104   3105   3106   3107   3108   3109   3110   3111   3112   3113 
##     0*      5   1500      0      0      0     0*     0*      0      0     10 
##   3114   3115   3116   3117   3118   3119   3120   3121   3122   3123   3124 
##      5      0      0     10      0     0*      0      0     20      0      0 
##   3125   3126   3127   3128   3129   3130   3131   3132   3133   3134   3135 
##      0      0      0      0    150     0*      0      0      0      0      0 
##   3136   3137   3138   3139   3140   3141   3142   3143   3144   3145   3146 
##     10      0      0  11500      0     0*      0      0     0*     0*      0 
##  3147  3148  3149  3150  3151  3152  3153  3154  3155  3156  3157 
##     0     0     0     0   500    0*    0*     0     0     0   300 
##  3158  3159  3160  3161  3162  3163  3164  3165  3166  3167  3168 
##     0    20  1200    0*     0  5500    50     0     0     0     0 
##  3169  3170  3171  3172  3173  3174  3175  3176  3177  3178  3179 
##     0     0     0     0    0*     0     0     0    0*    35     0 
##  3180  3181  3182  3183  3184  3185  3186  3187  3188  3189  3190 
##     0    0*  1500    0*    0*   100    0*     0   500     0   200 
##  3191  3192  3193  3194  3195  3196  3197  3198  3199  3200  3201 
##     0    0*     0    0*     0     0    50   500    10    75     0 
##  3202  3203  3204  3205  3206  3207  3208  3209  3210  3211  3212 
##     0   600    0*     0     0     0    0*     0     0     0   100 
##  3213  3214  3215  3216  3217  3218  3219  3220  3221  3222  3223 
##     0     0     0     0     0     0    0*     0     0 11000    0* 
##  3224  3225  3226  3227  3228  3229  3230  3231  3232  3233  3234 
##    0*     0     0     0  9700     0     0   100     0     0   100 
##  3235  3236  3237  3238  3239  3240  3241  3242  3243  3244  3245 
##     0     0   500     0     0     0     0     0     0     0     0 
##  3246  3247  3248  3249  3250  3251  3252  3253  3254  3255  3256 
##     0    0*     0     0     0     0     0     0     0     0     0 
##  3257  3258  3259  3260  3261  3262  3263  3264  3265  3266  3267 
##     0    10     0    0*     0    0*     0     0     0     0     0 
##  3268  3269  3270  3271  3272  3273  3274  3275  3276  3277  3278 
##   500     0     0    0*  2400     0     0     0     0     0     0 
##  3279  3280  3281  3282  3283  3284  3285  3286  3287  3288  3289 
##     0     0    30     0     0     0     0     0   200     0     0 
##  3290  3291  3292  3293  3294  3295  3296  3297  3298  3299  3300 
##     0     0     0     0     0     0     0     0     0     0     0 
##  3301  3302  3303  3304  3305  3306  3307  3308  3309  3310  3311 
##    0*     0     0     0     0     0     5    40     0     0     0 
##  3312  3313  3314  3315  3316  3317  3318  3319  3320  3321  3322 
##    0*     0    0*     0     0     0     0     0     0     0    0* 
##  3323  3324  3325  3326  3327  3328  3329  3330  3331  3332  3333 
##     0    0*     0    0*    50     0     0     0     0    0*     0 
##  3334  3335  3336  3337  3338  3339  3340  3341  3342  3343  3344 
##     0     0     0     0     0     0     0     0  7000     0    0* 
##  3345  3346  3347  3348  3349  3350  3351  3352  3353  3354  3355 
##   300    0*     0   400    0*    0*   700     0     0     0   300 
##  3356  3357  3358  3359  3360  3361  3362  3363  3364  3365  3366 
##    25     0    0*  1000    0* 10000     0     0     0     0    0* 
##  3367  3368  3369  3370  3371  3372  3373  3374  3375  3376  3377 
##   400    0*     0     0   150    0*    0*     0  1500    0*     0 
##  3378  3379  3380  3381  3382  3383  3384  3385  3386  3387  3388 
##    0*    0*    30    0*     0    75     0     0     0    50     0 
##  3389  3390  3391  3392  3393  3394  3395  3396  3397  3398  3399 
##    0*     0     0     0    0*    0*    0*     0     0     0     0 
##  3400  3401  3402  3403  3404  3405  3406  3407  3408  3409  3410 
##     0     0  8000     0     0     0    20    0*    10    0*    0* 
##  3411  3412  3413  3414  3415  3416  3417  3418  3419  3420  3421 
## 13000     0     0     0     0    0*     0    0*     0     0    0* 
##  3422  3423  3424  3425  3426  3427  3428  3429  3430  3431  3432 
##     0     0     0     0    0*     0     0    0*     0    50     0
##   3433   3434   3435   3436   3437   3438   3439   3440   3441   3442   3443 
##      0      0      0     0*      0     15      0      0      0      0      0 
##   3444   3445   3446   3447   3448   3449   3450   3451   3452   3453   3454 
##      0      0      0      0     0*      0      0      0      0      0      0 
##   3455   3456   3457   3458   3459   3460   3461   3462   3463   3464   3465 
##      0     0*    100      0      0      0      0      0      0      0      0 
##   3466   3467   3468   3469   3470   3471   3472   3473   3474   3475   3476 
##   1000      0      0      0      0      0      0      0     0*      0      0 
##   3477   3478   3479   3480   3481   3482   3483   3484   3485   3486   3487 
##     0*     0*      0      0   1000      0      0      0      0    300      0 
##   3488   3489   3490   3491   3492   3493   3494   3495   3496   3497   3498 
##      0      0     0*      0      0      0    300      0      0    100      0 
##   3499   3500   3501   3502   3503   3504   3505   3506   3507   3508   3509 
##      0      0    500      0      0     0*      0      5      0      0     70 
##   3510   3511   3512   3513   3514   3515   3516   3517   3518   3519   3520 
##     0*     0*     0*      0      0    200     0*      0      0     0*      0 
##   3521   3522   3523   3524   3525   3526   3527   3528   3529   3530   3531 
##    600     0*      0      0    200      0      0    500     70      0    400 
##   3532   3533   3534   3535   3536   3537   3538   3539   3540   3541   3542 
##  10000      0      0      0  11000      0     0*      0      0      0      0 
##   3543   3544   3545   3546   3547   3548   3549   3550   3551   3552   3553 
##      0      0      0      0      0     0*     0*     0*  12000     0*     0* 
##   3554   3555   3556   3557   3558   3559   3560   3561   3562   3563   3564 
##      0     0*      0     0*      0      0     0*      0      0      0      0 
##   3565   3566   3567   3568   3569   3570   3571   3572   3573   3574   3575 
##     0*      0     0*     0*     0*      0      0      0     0*     0*      0 
##   3576   3577   3578   3579   3580   3581   3582   3583   3584   3585   3586 
##      0      0      0      0     0*      0      0      0      0      0     20 
##   3587   3588   3589   3590   3591   3592   3593   3594   3595   3596   3597 
##      0    400      0      0      0      0     0*      0      0      0      0 
##   3598   3599   3600   3601   3602   3603   3604   3605   3606   3607   3608 
##      0      0      0      0    300      0      0      0      0      0      0 
##   3609   3610   3611   3612   3613   3614   3615   3616   3617   3618   3619 
##      0      0     0*      0      0      0      0      0      0      0      0 
##   3620   3621   3622   3623   3624   3625   3626   3627   3628   3629   3630 
##  10000      0     0*      0     0*      0      7   9000      0      0    100 
##   3631   3632   3633   3634   3635   3636   3637   3638   3639   3640   3641 
##     0*      0      0      0      0      0      0     0*     0*      0      0 
##   3642   3643   3644   3645   3646   3647   3648   3649   3650   3651   3652 
##     0*      0     0*     0*     0*      0      0      0      0      0      0 
##   3653   3654   3655   3656   3657   3658   3659   3660   3661   3662   3663 
##      0     0*     0*      0      0      0     0*     0*      0      0   1000 
##   3664   3665   3666   3667   3668   3669   3670   3671   3672   3673   3674 
##      0      0  16000      0     35   8000      0      0      0      0   1500 
##   3675   3676   3677   3678   3679   3680   3681   3682   3683   3684   3685 
##      0      0      0    300     0*      0     0*     0*    200     0*   1200 
##   3686   3687   3688   3689   3690   3691   3692   3693   3694   3695   3696 
##   1000   1500   1000      0      0      0      0     0*   3000      0     10 
##   3697   3698   3699   3700   3701   3702   3703   3704   3705   3706   3707 
##     0*      0     0*      0      0      0      0      0      0  11000      0 
##   3708   3709   3710   3711   3712   3713   3714   3715   3716   3717   3718 
##  15000      0      0      0      0     0*      0      0      0     0*      0 
##   3719   3720   3721   3722   3723   3724   3725   3726   3727   3728   3729
##      0      0      0    300      0      0   1600      0      0     0*      0
##   3730   3731   3732   3733   3734   3735   3736   3737   3738   3739   3740
##      0      0      0      0      0      0      5   4600      0      0      0
##   3741   3742   3743   3744   3745   3746   3747   3748   3749   3750   3751
##      0      0      0      0      0     0*      0      0     0*     27      0
##   3752   3753   3754   3755   3756   3757   3758   3759   3760   3761   3762
##     0*      0      0      0      0    300      0   5900     0*      0     0*
##   3763   3764   3765   3766   3767   3768   3769   3770   3771   3772   3773
##     0*      0      0      0      0      0     0*    100      0      0      0
##   3774   3775   3776   3777   3778   3779   3780   3781   3782   3783   3784
##      0     0*      0      0      0   1000     0*     30      0      0      0
##   3785   3786   3787   3788   3789   3790   3791   3792   3793   3794   3795
##      0      0     0*      0     0*     0*      0   2000     0*      0    700
##   3796   3797   3798   3799   3800   3801   3802   3803   3804   3805   3806
##      0    300    300     0*      0     0*      0      0      0      0      0
##   3807   3808   3809   3810   3811   3812   3813   3814   3815   3816   3817
##      0      0      0     0*      0      0      0      0     0*      0     0*
##   3818   3819   3820   3821   3822   3823   3824   3825   3826   3827   3828
##      0      0     0*    800      0     0*     0*      0     0*      0      0
##   3829   3830   3831   3832   3833   3834   3835   3836   3837   3838   3839
##      0      0     20    680      0      0     0*     0*     50    200     0*
##   3840   3841   3842   3843   3844   3845   3846   3847   3848   3849   3850
##      0   7500   2100      0  12000     0*     50      0   3000      0      0
##   3851   3852   3853   3854   3855   3856   3857   3858   3859   3860   3861
##     0*     0*      0    500      0   1700      0      0   3000    100     0*
##   3862   3863   3864   3865   3866   3867   3868   3869   3870   3871   3872
##   3000     0*      0     0*    200      0     0*     0*      0      0    400
##   3873   3874   3875   3876   3877   3878   3879   3880   3881   3882   3883
##      0  11000      0      0      0   8000     0*     0*     20      0      0
##   3884   3885   3886   3887   3888   3889   3890   3891   3892   3893   3894
##      0     20     0*      0      0      0      0      0      0      0      0
##   3895   3896   3897   3898   3899   3900   3901   3902   3903   3904   3905
##      0      0      0    100    400      0      0      0      0      0      0
##   3906   3907   3908   3909   3910   3911   3912   3913   3914   3915   3916
##      0      0      0      0      0      0      0      0     0*      0      0
##   3917   3918   3919   3920   3921   3922   3923   3924   3925   3926   3927
##      0      0      0     20    500     0*     0*     0*      0      0     0*
##   3928   3929   3930   3931   3932   3933   3934   3935   3936   3937   3938
##      0      0      0      0      0      0     0*      0      0     0*      0
##   3939   3940   3941   3942   3943   3944   3945   3946   3947   3948   3949
##     10      0      0      0      0      0      0      0      0     0*      0
##   3950   3951   3952   3953   3954   3955   3956   3957   3958   3959   3960
##    600      0      0    200      0      0      0      0      0    500    800
##   3961   3962   3963   3964   3965   3966   3967   3968   3969   3970   3971
##     0*      0    250     0*     0*     0*     0*      0      0      0     0*
##   3972   3973   3974   3975   3976   3977   3978   3979   3980   3981   3982
##     10      0     0*     20    800     0*      0      0     0*      0     0*
##   3983   3984   3985   3986   3987   3988   3989   3990   3991   3992   3993
##      0     0*   1000     0*      0      0     0*     0*      0   2000   1200
##   3994   3995   3996   3997   3998   3999   4000   4001   4002   4003   4004
##      0     0*   1500     0*   9000      0      0      0   1000      0      0
##   4005   4006   4007   4008   4009   4010   4011   4012   4013   4014   4015 
##     0*      0      0     0*     0*   1100      0      0      0      0      0 
##   4016   4017   4018   4019   4020   4021   4022   4023   4024   4025   4026 
##     0*      0      0      0      0      0      0     0*      0      0      0 
##   4027   4028   4029   4030   4031   4032   4033   4034   4035   4036   4037 
##      0     0*      0      0      0      0     0*      0      0      0     0* 
##   4038   4039   4040   4041   4042   4043   4044   4045   4046   4047   4048 
##      0     0*     0*     0*     0*     0*     0*     0*   9500     0*     0* 
##   4049   4050   4051   4052   4053   4054   4055   4056   4057   4058   4059 
##     0*      0      0      0      0      0      0      0    100     0*      0 
##   4060   4061   4062   4063   4064   4065   4066   4067   4068   4069   4070 
##     0*      0      0      0    200     0*      0      0     30     50      0 
##   4071   4072   4073   4074   4075   4076   4077   4078   4079   4080   4081 
##     50     0*    300     0*      0      0    500     0*     0*     0*     0* 
##   4082   4083   4084   4085   4086   4087   4088   4089   4090   4091   4092 
##      0      5      0      0     50     0*     0*     20     0*      0     0* 
##   4093   4094   4095   4096   4097   4098   4099   4100   4101   4102   4103 
##      0      0     0*     0*     0*     0*     0*     0*      0    200      0 
##   4104   4105   4106   4107   4108   4109   4110   4111   4112   4113   4114 
##     0*     0*     0*      0      0     0*      0      0     0*    100      0 
##   4115   4116   4117   4118   4119   4120   4121   4122   4123   4124   4125 
##     0*     0*      0     0*      0     0*      0     0*     0*      0     0* 
##   4126   4127   4128   4129   4130   4131   4132   4133   4134   4135   4136 
##      0      0      0    800      0      0      0    300   3000   3000      0 
##   4137   4138   4139   4140   4141   4142   4143   4144   4145   4146   4147 
##      0      0     0*     0*      0      0      0      0      0      0     0* 
##   4148   4149   4150   4151   4152   4153   4154   4155   4156   4157   4158 
##     50      0      0   7000      0      0      0      0     0*    100      0 
##   4159   4160   4161   4162   4163   4164   4165   4166   4167   4168   4169 
##   8000      0      0    300     0*      0     0*     0*      0     0*      0 
##   4170   4171   4172   4173   4174   4175   4176   4177   4178   4179   4180 
##     50     0*     0*   5960     0*     0*      0   7600      0      0     0* 
##   4181   4182   4183   4184   4185   4186   4187   4188   4189   4190   4191 
##     0*      0   7600      0      0      0      0      0      0      0      0 
##   4192   4193   4194   4195   4196   4197   4198   4199   4200   4201   4202 
##      0     0*      0      0      0      0     0*      0      0     0*      0 
##   4203   4204   4205   4206   4207   4208   4209   4210   4211   4212   4213 
##    200    400   3500      0      0     0*    500     0*      0      0     0* 
##   4214   4215   4216   4217   4218   4219   4220   4221   4222   4223   4224 
##      0      0     0*      0      0      0      0      0     0*      0      0 
##   4225   4226   4227   4228   4229   4230   4231   4232 
##    350     0*     0*     0*      5     0*      0   6600
```

One sample T-test on height of aircraft

We are testing to see whether the mean of one sample is the same as a theoretical population mean. Usually, the population mean is obtained from a prior study or given control/treatment conditions, you may represent your data as “percent of control”, and test for whether the average value of treatment condition significantly varies from 100. You can find more here (http://www.sthda.com/english/wiki/one-sample-t-test-in-r)

Let’s check one-sample t-test assumptions. Since our sample size is much higher than 30, we can skip this. However, if the sample size is small you can use a Shapiro-Wilk normality test. For this test: Ho: the data are normally distributed H1: the data are not normally distributed

If the p-value is greater than alpha=0.05, this means that the distribution of the data are not significantly different from normal distribution. We can assume normality for height. For the purposes of demonstration, we’ll run it here. ## Check the Distribution of data assumption

```
shapiro.test(new_data_amass$height)
```

```
## 
##  Shapiro-Wilk normality test
## 
## data:  new_data_amass$height
## W = 0.23369, p-value < 2.2e-16
```

Since we don’t have a theoretical value for the population mean, a value of 0 is used. We test whether the average height of aircraft differs from 0.

```
summary(new_data_amass$height)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's 
##  0.0000  0.0000  0.0000  0.7028  0.0000 25.0000     817
```

```
t.test(new_data_amass$height, mu=0, alternative = "two.sided")   ## gives the 95 percent CI as the default
```

```
## 
##  One Sample t-test
## 
## data:  new_data_amass$height
## t = 11.456, df = 2627, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  0.5825203 0.8231113
## sample estimates:
## mean of x 
## 0.7028158
```

Since this tiny p-value is below the significance alpha level =0.05, it tells us that the average height of aircraft is significantly different from 0.

Another way to conduct a this hypothesis test is using the t critical value.

Let’s compute a 95th confidence interval using the t critical value. Are the CIs the same or different?

```
xbar = mean(new_data_amass$height, na.rm=TRUE)
se_xbar = sd(new_data_amass$height, na.rm=TRUE)/sqrt(no_nas(new_data_amass$height))
lower = xbar - qt(0.975, df = no_nas(new_data_amass$height)-1)*se_xbar
upper = xbar + qt(0.975, df = no_nas(new_data_amass$height)-1)*se_xbar
c(lower, upper)
```

```
## [1] 0.5825203 0.8231113
```

We can conclude from the one sample t-test that the average height of aircraft is statistically significantly different from a theoretical population mean of 0. The sample mean is between 0.58 and 0.83.

Sometimes it maybe helpful to collapse certain categories into one. We can take a look at the categories of damage_level and see that categories we may combine

```
unique(new_data_amass$damage_level)
```

```
## [1] "N"  NA   "M?" "M"  "S"
```

```
new_data_amass$damage_level<-case_when(new_data_amass$damage_level %in% c("M?", "M") ~ "M",
                TRUE ~ new_data_amass$damage_level)
unique(new_data_amass$damage_level)
```

```
## [1] "N" NA  "M" "S"
```

Finally, let’s save our modified file to a csv file.

```
library(data.table)
fwrite(new_data_amass,"new_data.csv")
```

Discussion Activity:

1. a. Focus on the collisions with one and two engine planes.
   b. Remove outliers using one the methods shown in the demo.
   c. Did you decide if you want to impute values? Tell us what you decided on.
   d. Compute the average and standard deviation of the speed variable.
2. Compute a 95 percent confidence interval for the difference in mean speed at collision between one-engine and two-engine airplanes.
3. Using the data from the distance variable, conduct a one sample t-test for the mean speed of all bird-airplane collisions.

a. What is the conclusion of the one sample t-test?

Find Unique number of engines in data set

```
unique(data$num_engs)
```

```
## [1] NA  2  3  1  4
```

Use tapply() to filter for only 1 or 2 engines. Also compute the mean distance and SD for birds that were struck.

```
eng12 = data[data$num_engs  %in% c(1,2), ]
tapply(eng12$distance, eng12$num_struck, mean, na.rm=TRUE)
```

```
##         1    11-100      2-10
## 0.4757197 0.1176471 0.2095344
```

```
tapply(eng12$distance, eng12$num_struck, sd, na.rm=TRUE)
```

```
##         1    11-100      2-10
## 2.5934032 0.3321056 1.6576081
```

Remove NAs

```
no_nas = function(x){
  return(sum(!is.na(x)))
}
summary(eng12$num_engs)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.000   2.000   2.000   1.999   2.000   2.000
```

compute a Confidence interval for difference in means for distance in the reduced data set.

```
xbarz_12 = tapply(eng12$distance, eng12$num_engs, mean, na.rm=TRUE)
sez_12 = tapply(eng12$distance, eng12$num_engs, sd, na.rm=TRUE)/sqrt(tapply(eng12$distance, eng1
2$num_engs, no_nas))
xbarz_12
```

```
##         1         2
## 0.0000000 0.4352752
```

```
sez_12
```

```
##          1          2
## 0.00000000 0.04439063
```

Compute the difference in means for distance and the standard error of the difference using the z statistic.

```
diff_meanz_12 = xbarz_12[2] - xbarz_12[1]       ## compute the difference in means
se_diff_12    = sqrt(sez_12[2]^2+sez_12[1]^2)   ## compute the standard error of the difference
lower_12 = diff_meanz_12 - 1.96*se_diff_12      ## lower part of the interval
upper_12 = diff_meanz_12 + 1.96*se_diff_12      ## upper part of the interval

c(lower_12, upper_12)
```

```
##         2         2
## 0.3482696 0.5222808
```

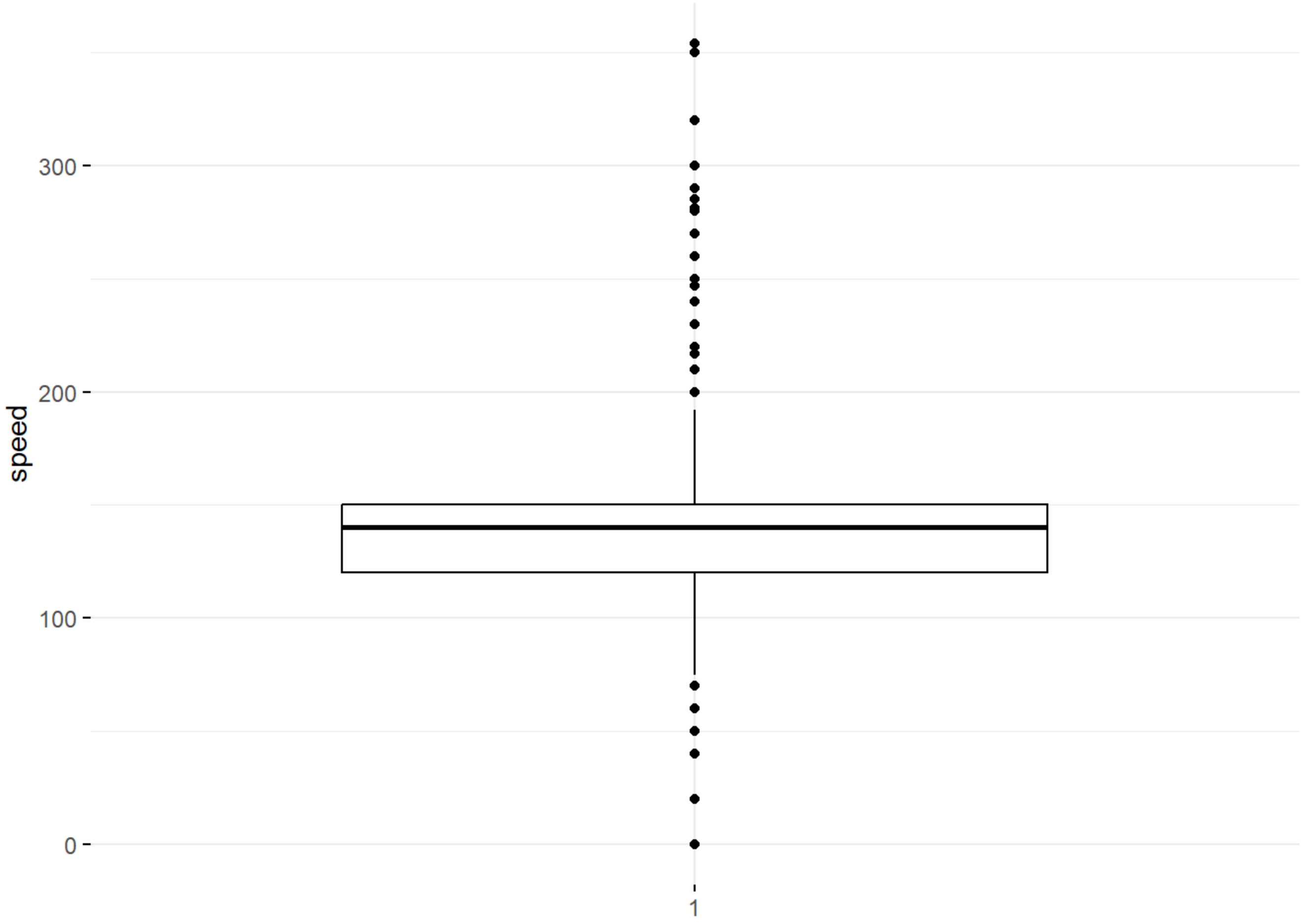
Use a two-sample t-test to compute a difference in means using the base function in R.

```
t.test(eng12$speed,alternative = "two.sided")   ## gives the 95 percent CI as the default
```

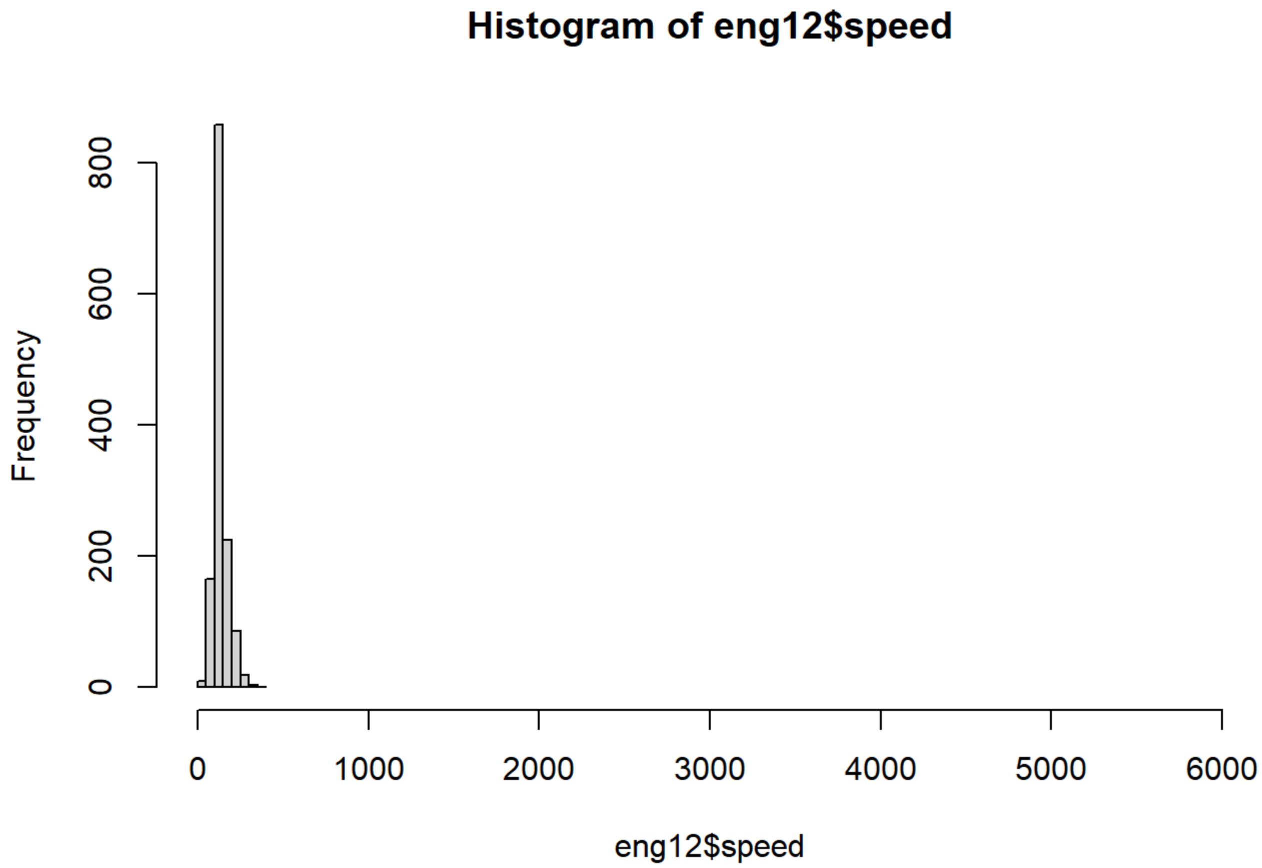
```
##
##  One Sample t-test
##
## data:  eng12$speed
## t = 132.95, df = 1363, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  140.5990 144.8101
## sample estimates:
## mean of x
##  142.7045
```

```
ggboxplot(eng12$speed,
          ylab = "speed", xlab = FALSE,
          ggtheme = theme_minimal())
```

```
## Warning: Removed 2731 rows containing non-finite outside the scale range
## (`stat_boxplot()`).
```



```
hist(eng12$speed, xlim=c(0,6000))
```



```
Q_12 <- quantile(eng12$speed, probs=c(.25, .75), na.rm = TRUE)
iqr_12 <- IQR(eng12$speed, na.rm = TRUE)
iqr_12
```

```
## [1] 30
```

```
up_12 <-  Q_12[2]+1.5*iqr # Upper Range
low_12 <- Q_12[1]-1.5*iqr # Lower Range
```

```
new_eng12<- subset(eng12, eng12$speed > (Q[1] - 1.5*iqr) & eng12$speed < (Q[2]+1.5*iqr))
```

```
impute(new_eng12$speed, median)
```

```
## [1]  0  0  0  0  0 20
```

```
summary(new_eng12$speed)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##   0.000   0.000   0.000   3.333   0.000  20.000
```

```
t.test(new_eng12$speed, mu=0, alternative = "two.sided")   ## gives the 95 percent CI as the default
```

```
##
##  One Sample t-test
##
## data:  new_eng12$speed
## t = 1, df = 5, p-value = 0.3632
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -5.235273 11.901939
## sample estimates:
## mean of x
##  3.333333
```

The p-value is below the significance alpha level =0.05, this means that the average speed of all bird-airplane collisions is different from 0.