Main Data

Load the data, and take a look.

```
train <- read.csv("../data/train.csv")
test <- read.csv("../data/test.csv")
dim(train)
```

```
## [1] 10506    12
```

```
dim(test)
```

```
## [1] 116293     11
```

```
head(train)
```

```
##         Date                                              Address
## 1 2007-05-29 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 2 2007-05-29 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 3 2007-05-29  6200 North Mandell Avenue, Chicago, IL 60646, USA
## 4 2007-05-29    7900 West Foster Avenue, Chicago, IL 60656, USA
## 5 2007-05-29    7900 West Foster Avenue, Chicago, IL 60656, USA
## 6 2007-05-29   1500 West Webster Avenue, Chicago, IL 60614, USA
##                   Species Block          Street Trap
## 1 CULEX PIPIENS/RESTUANS    41  N OAK PARK AVE T002
## 2         CULEX RESTUANS    41  N OAK PARK AVE T002
## 3         CULEX RESTUANS    62   N MANDELL AVE T007
## 4 CULEX PIPIENS/RESTUANS    79    W FOSTER AVE T015
## 5         CULEX RESTUANS    79    W FOSTER AVE T015
## 6         CULEX RESTUANS    15   W WEBSTER AVE T045
##              AddressNumberAndStreet Latitude Longitude AddressAccuracy
## 1 4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 2 4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 3  6200  N MANDELL AVE, Chicago, IL 41.99499 -87.76928               9
## 4   7900  W FOSTER AVE, Chicago, IL 41.97409 -87.82481               8
## 5   7900  W FOSTER AVE, Chicago, IL 41.97409 -87.82481               8
## 6  1500  W WEBSTER AVE, Chicago, IL 41.92160 -87.66645               8
##   NumMosquitos WnvPresent
## 1            1          0
## 2            1          0
## 3            1          0
## 4            1          0
## 5            4          0
## 6            2          0
```

```
head(test, 10)
```

```
##    Id       Date                                              Address
## 1   1 2008-06-11 4100 North Oak Park Avenue, Chicago, IL 60634, USA
```

```
## 2   2 2008-06-11 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 3   3 2008-06-11 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 4   4 2008-06-11 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 5   5 2008-06-11 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 6   6 2008-06-11 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 7   7 2008-06-11 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 8   8 2008-06-11 4100 North Oak Park Avenue, Chicago, IL 60634, USA
## 9   9 2008-06-11  6200 North Mandell Avenue, Chicago, IL 60646, USA
## 10 10 2008-06-11  6200 North Mandell Avenue, Chicago, IL 60646, USA
##                   Species Block          Street Trap
## 1  CULEX PIPIENS/RESTUANS    41  N OAK PARK AVE T002
## 2          CULEX RESTUANS    41  N OAK PARK AVE T002
## 3           CULEX PIPIENS    41  N OAK PARK AVE T002
## 4         CULEX SALINARIUS    41  N OAK PARK AVE T002
## 5          CULEX TERRITANS    41  N OAK PARK AVE T002
## 6           CULEX TARSALIS    41  N OAK PARK AVE T002
## 7        UNSPECIFIED CULEX    41  N OAK PARK AVE T002
## 8          CULEX ERRATICUS    41  N OAK PARK AVE T002
## 9  CULEX PIPIENS/RESTUANS    62   N MANDELL AVE T007
## 10         CULEX RESTUANS    62   N MANDELL AVE T007
##               AddressNumberAndStreet Latitude Longitude AddressAccuracy
## 1  4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 2  4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 3  4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 4  4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 5  4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 6  4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 7  4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 8  4100  N OAK PARK AVE, Chicago, IL 41.95469 -87.80099               9
## 9   6200  N MANDELL AVE, Chicago, IL 41.99499 -87.76928               9
## 10  6200  N MANDELL AVE, Chicago, IL 41.99499 -87.76928               9
```

```
str(train, strict.width="cut")
```

```
## 'data.frame':    10506 obs. of  12 variables:
##  $ Date                   : Factor w/ 95 levels "2007-05-29","2007-06-05",..
##  $ Address                : Factor w/ 138 levels "1000 East 67th Street, "..
##  $ Species                : Factor w/ 7 levels "CULEX ERRATICUS",..: 3 4 4..
##  $ Block                  : int  41 41 62 79 79 15 25 11 11 11 ...
##  $ Street                 : Factor w/ 128 levels " E 105TH ST",..: 33 33 2..
##  $ Trap                   : Factor w/ 136 levels "T001","T002",..: 2 2 7 1..
##  $ AddressNumberAndStreet: Factor w/ 138 levels "1000  E 67TH ST, Chicag"..
##  $ Latitude               : num  42 42 42 42 42 ...
##  $ Longitude              : num  -87.8 -87.8 -87.8 -87.8 -87.8 ...
##  $ AddressAccuracy        : int  9 9 9 8 8 8 8 8 8 8 ...
##  $ NumMosquitos           : int  1 1 1 1 4 2 1 1 2 1 ...
##  $ WnvPresent             : int  0 0 0 0 0 0 0 0 0 0 ...
```

```
str(test, strict.width="cut")
```

```
## 'data.frame':    116293 obs. of  11 variables:
##  $ Id                     : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Date                   : Factor w/ 95 levels "2008-06-11","2008-06-17",..
```

```
##  $ Address               : Factor w/ 151 levels "1000 East 67th Street, "..
##  $ Species               : Factor w/ 8 levels "CULEX ERRATICUS",..: 3 4 2..
##  $ Block                 : int  41 41 41 41 41 41 41 41 62 62 ...
##  $ Street                : Factor w/ 139 levels " E 105TH ST",..: 37 37 3..
##  $ Trap                  : Factor w/ 149 levels "T001","T002",..: 2 2 2 2..
##  $ AddressNumberAndStreet: Factor w/ 151 levels "1000  E 67TH ST, Chicag"..
##  $ Latitude              : num  42 42 42 42 42 ...
##  $ Longitude             : num  -87.8 -87.8 -87.8 -87.8 -87.8 ...
##  $ AddressAccuracy       : int  9 9 9 9 9 9 9 9 9 9 ...
```

And there is no missing value.

```
any(is.na(train) == TRUE)
```

```
## [1] FALSE
```

```
any(is.na(test) == TRUE)
```

```
## [1] FALSE
```

Feature Engineering

Date

```
train$Date <- as.Date(train$Date)
test$Date <- as.Date(test$Date)
```

Naturally, we create four features Year, Month, Week and Weekday based on Date.

```
library(lubridate)
## train set
train$Year <- as.integer(year(train$Date))
train$Month <- factor(months(train$Date),
                      levels=c("May", "June", "July", "August", "September", "October"))
train$Week <- week(train$Date)
train$Weekday <- factor(weekdays(train$Date),
                        levels=c("Monday", "Tuesday", "Wednesday", "Thursday", "Friday"))
## test set
test$Year <- as.integer(year(test$Date))
test$Month <- factor(months(test$Date),
                     levels=c("June", "July", "August", "September", "October"))
test$Week <- week(test$Date)
test$Weekday <- factor(weekdays(test$Date),
                       levels=c("Monday", "Tuesday", "Wednesday", "Thursday", "Friday"))
## take a look
head(train[,c("Date", "Year", "Month", "Week", "Weekday")])
```

```
##         Date Year Month Week Weekday
## 1 2007-05-29 2007   May   22 Tuesday
```

```
## 2 2007-05-29 2007   May   22 Tuesday
## 3 2007-05-29 2007   May   22 Tuesday
## 4 2007-05-29 2007   May   22 Tuesday
## 5 2007-05-29 2007   May   22 Tuesday
## 6 2007-05-29 2007   May   22 Tuesday
```

```
head(test[,c("Date", "Year", "Month", "Week", "Weekday")])
```

```
##         Date Year Month Week   Weekday
## 1 2008-06-11 2008  June   24 Wednesday
## 2 2008-06-11 2008  June   24 Wednesday
## 3 2008-06-11 2008  June   24 Wednesday
## 4 2008-06-11 2008  June   24 Wednesday
## 5 2008-06-11 2008  June   24 Wednesday
## 6 2008-06-11 2008  June   24 Wednesday
```

```
str(train[,c("Date", "Year", "Month", "Week", "Weekday")])
```

```
## 'data.frame':    10506 obs. of  5 variables:
##  $ Date   : Date, format: "2007-05-29" "2007-05-29" ...
##  $ Year   : int  2007 2007 2007 2007 2007 2007 2007 2007 2007 2007 ...
##  $ Month  : Factor w/ 6 levels "May","June","July",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Week   : num  22 22 22 22 22 22 22 22 22 22 ...
##  $ Weekday: Factor w/ 5 levels "Monday","Tuesday",..: 2 2 2 2 2 2 2 2 2 2 ...
```

```
str(test[,c("Date", "Year", "Month", "Week", "Weekday")])
```

```
## 'data.frame':    116293 obs. of  5 variables:
##  $ Date   : Date, format: "2008-06-11" "2008-06-11" ...
##  $ Year   : int  2008 2008 2008 2008 2008 2008 2008 2008 2008 2008 ...
##  $ Month  : Factor w/ 5 levels "June","July",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Week   : num  24 24 24 24 24 24 24 24 24 24 ...
##  $ Weekday: Factor w/ 5 levels "Monday","Tuesday",..: 3 3 3 3 3 3 3 3 3 3 ...
```

Species

As a factor, Species has 7 levels in train set, but 8 levels in test set. The extra one in test set is "UNSPECIFIED CULEX".

```
table(train$Species)
```

```
##
##        CULEX ERRATICUS          CULEX PIPIENS CULEX PIPIENS/RESTUANS
##                      1                   2699                   4752
##         CULEX RESTUANS       CULEX SALINARIUS         CULEX TARSALIS
##                   2740                     86                      6
##        CULEX TERRITANS
##                    222
```

```
table(test$Species)
```

```
##
##        CULEX ERRATICUS          CULEX PIPIENS CULEX PIPIENS/RESTUANS
##                  14345                  14521                  15359
##         CULEX RESTUANS       CULEX SALINARIUS         CULEX TARSALIS
##                  14670                  14355                  14347
##        CULEX TERRITANS      UNSPECIFIED CULEX
##                  14351                  14345
```

The "UNSPECIFIED CULEX" does not appear in the train set. We need a mechanism to specify it to another level, which is one of the 7 levels in train set. Right now we use the following strategy.

```
test[test$Species=="UNSPECIFIED CULEX", "Species"] <- "CULEX ERRATICUS"
```

NumMosquitos

These train results are organized in such a way that when the number of mosquitos exceed 50, they are split into another record (another row in the dataset), such that the number of mosquitos are capped at 50. For the test set, it is the same, while NumMosquitos does not appear as a predictor.

The following records in training set tells us sometime they didn't use 50 as unit to split data!

```
train[294:299,]
```

```
##           Date                                          Address
## 294 2007-07-11 2200 West 113th Street, Chicago, IL 60643, USA
## 295 2007-07-11 2200 West 113th Street, Chicago, IL 60643, USA
## 296 2007-07-11 2200 West 113th Street, Chicago, IL 60643, USA
## 297 2007-07-11 2200 West 113th Street, Chicago, IL 60643, USA
## 298 2007-07-11 2200 West 113th Street, Chicago, IL 60643, USA
## 299 2007-07-11 2200 West 113th Street, Chicago, IL 60643, USA
##                     Species Block      Street Trap
## 294 CULEX PIPIENS/RESTUANS    22  W 113TH ST T086
## 295 CULEX PIPIENS/RESTUANS    22  W 113TH ST T086
## 296 CULEX PIPIENS/RESTUANS    22  W 113TH ST T086
## 297 CULEX PIPIENS/RESTUANS    22  W 113TH ST T086
## 298         CULEX RESTUANS    22  W 113TH ST T086
## 299         CULEX RESTUANS    22  W 113TH ST T086
##             AddressNumberAndStreet Latitude Longitude AddressAccuracy
## 294 2200  W 113TH ST, Chicago, IL 41.68832 -87.67671               8
## 295 2200  W 113TH ST, Chicago, IL 41.68832 -87.67671               8
## 296 2200  W 113TH ST, Chicago, IL 41.68832 -87.67671               8
## 297 2200  W 113TH ST, Chicago, IL 41.68832 -87.67671               8
## 298 2200  W 113TH ST, Chicago, IL 41.68832 -87.67671               8
## 299 2200  W 113TH ST, Chicago, IL 41.68832 -87.67671               8
##     NumMosquitos WnvPresent Year Month Week   Weekday
## 294           50          0 2007  July   28 Wednesday
## 295           35          0 2007  July   28 Wednesday
## 296           50          0 2007  July   28 Wednesday
## 297            8          0 2007  July   28 Wednesday
## 298            1          0 2007  July   28 Wednesday
## 299            8          0 2007  July   28 Wednesday
```

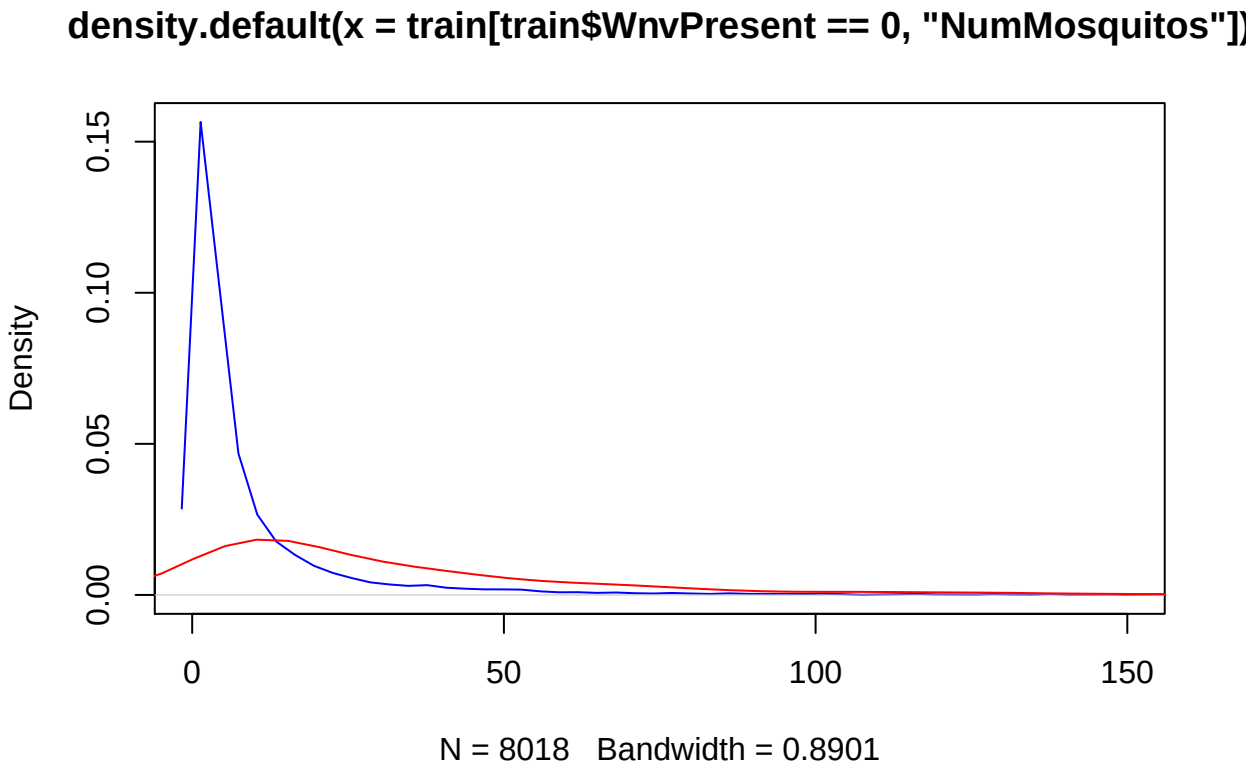
```
library(plyr)
```

```
##
## Attaching package: 'plyr'
##
## The following object is masked from 'package:lubridate':
##
##     here
```

```
train <- ddply(train,
.(Date, Address, Species, Block, Street, Trap,
AddressNumberAndStreet, Latitude, Longitude,
AddressAccuracy, Year, Month, Week, Weekday),
summarize,
NumMosquitos = sum(NumMosquitos),
WnvPresent = as.integer(as.logical(sum(WnvPresent)))
)
test[,"NumMosquitos"] <- 1
NumMosquitosCount <- ddply(test,
.(Date, Address, Species, Block, Street, Trap,
AddressNumberAndStreet, Latitude, Longitude,
AddressAccuracy, Year, Month, Week, Weekday),
summarize,
NumMosquitos = sum(NumMosquitos)
)[,"NumMosquitos"]
test[,"NumMosquitos"] <- rep(NumMosquitosCount, NumMosquitosCount)
## change scale
est.num <- function(num){
n1 <- (num-1)*50
n2 <- num*50
result <- mean(train[train$NumMosquitos>=n1 & train$NumMosquitos<=n2, "NumMosquitos"])
return(result)
}
mean.num <- sapply(1:26, est.num)
mean.num[18] <- 870
mean.num[23:26] <- c(1120, 1170, 1220, 1270)
test$NumMosquitos <- mean.num[test$NumMosquitos]
summary(test$NumMosquitos)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
##    7.361    7.361    7.361   26.380   67.290 1270.000
```

```
n0 <- length(train[train$WnvPresent==0,])
n1 <- length(train[train$WnvPresent==1,])
weight0 <- rep(1/(n0+n1), n0)
weight1 <- rep(1/(n0+n1), n1)
density0 <- density(train[train$WnvPresent==0, "NumMosquitos"])
density1 <- density(train[train$WnvPresent==1, "NumMosquitos"])
plot(density0, col="blue", xlim=c(0, 150))
lines(density1, col="red")
```



Trap

First, check out the names of all traps.

```
unique(train$Trap)
```

```
##   [1] T002  T007  T015  T045  T046  T048  T049  T050  T054  T086  T091
##  [12] T094  T096  T129  T143  T148  T153  T159  T009  T011  T016  T019
##  [23] T025  T028  T031  T033  T089  T090  T092  T135  T141  T142  T145
##  [34] T146  T147  T149  T150  T151  T152  T154  T158  T162  T218  T220
##  [45] T001  T003  T006  T008  T012  T034  T037  T040  T043  T047  T051
##  [56] T085  T088  T161  T219  T013  T014  T018  T030  T084  T144  T160
##  [67] T005  T017  T044  T095  T004  T035  T036  T039  T060  T061  T062
##  [78] T065  T066  T067  T069  T070  T071  T073  T074  T075  T076  T077
##  [89] T079  T080  T081  T082  T083  T114  T155  T063  T115  T138  T200
## [100] T206  T209  T212  T215  T107  T128  T072  T078  T097  T099  T100
## [111] T102  T103  T027  T156  T157  T221  T900  T903  T222  T223  T225
## [122] T227  T224  T226  T229  T230  T228  T232  T231  T235  T233  T236
## [133] T237  T238  T094B T054C
## 136 Levels: T001 T002 T003 T004 T005 T006 T007 T008 T009 T011 T012 ... T903
```

```
unique(test$Trap)
```

```
##   [1] T002  T007  T015  T045  T046  T048  T049  T050  T054  T086  T091
##  [12] T094  T096  T129  T143  T148  T153  T159  T009  T011  T016  T019
##  [23] T025  T028  T031  T033  T089  T090  T092  T135  T141  T142  T145
##  [34] T146  T147  T149  T150  T151  T152  T154  T158  T162  T218  T220
```

```
##  [45] T001  T003  T006  T008  T012  T034  T037  T040  T043  T047  T051
##  [56] T085  T088  T161  T219  T013  T014  T018  T030  T084  T144  T160
##  [67] T005  T017  T044  T095  T004  T035  T036  T039  T060  T061  T062
##  [78] T065  T066  T067  T069  T070  T071  T073  T074  T075  T076  T077
##  [89] T079  T080  T081  T082  T083  T114  T155  T063  T115  T138  T200
## [100] T206  T209  T212  T215  T107  T128  T072  T078  T097  T099  T100
## [111] T102  T103  T027  T156  T157  T221  T900  T903  T090A T090B T090C
## [122] T200A T128A T200B T218A T218C T218B T222  T223  T225  T227  T224
## [133] T226  T229  T230  T228  T231  T232  T002A T002B T233  T234  T235
## [144] T236  T237  T238  T065A T094B T054C
## 149 Levels: T001 T002 T002A T002B T003 T004 T005 T006 T007 T008 ... T903
```

Through the observation, we know that initial "T" is shared by all traps' names. The single letter after the 3 digits means this trap is a satellite trap of the main trap with the same 3 digits in the name.
Two new features can be naturally generated from this Trap feature:

- The main trap number (TrapNumber): the 3 digits;
- Main or satellite trap (TrapMS): the single letter after digits in Trap. If it is the main trap, there is no single letter. We label it "M".

```
## train set
train$TrapNumber <- as.integer(substr(as.character(train$Trap), 2, 4))
train$TrapMS <- as.factor(substr(as.character(train$Trap), 5, 5))
levels(train$TrapMS) <- c("M", "B", "C")
## test set
test$TrapNumber <- as.integer(substr(as.character(test$Trap), 2, 4))
test$TrapMS <- as.factor(substr(as.character(test$Trap), 5, 5))
levels(test$TrapMS) <- c("M", "A", "B", "C")
## show
head(train[,c("Trap", "TrapNumber", "TrapMS")])
```

```
##   Trap TrapNumber TrapMS
## 1 T002          2      M
## 2 T002          2      M
## 3 T007          7      M
## 4 T015         15      M
## 5 T015         15      M
## 6 T045         45      M
```

```
head(test[,c("Trap", "TrapNumber", "TrapMS")])
```

```
##   Trap TrapNumber TrapMS
## 1 T002          2      M
## 2 T002          2      M
## 3 T002          2      M
## 4 T002          2      M
## 5 T002          2      M
## 6 T002          2      M
```

Distances to the two weather stations

- Weather station 1: Lat: 41.995 Lon: -87.933

- Weather station 2: Lat: 41.786 Lon: -87.752

```
## Calculate distance in kilometers between two points
## (Unit is km, but it doesn't matter)
## From https://conservationecology.wordpress.com/2013/06/30/distance-between-two-points-in-r/
earth.dist <- function (long1, lat1, long2, lat2)
{
rad <- pi/180
a1 <- lat1 * rad
a2 <- long1 * rad
b1 <- lat2 * rad
b2 <- long2 * rad
dlon <- b2 - a2

dlat <- b1 - a1
a <- (sin(dlat/2))^2 + cos(a1) * cos(b1) * (sin(dlon/2))^2
c <- 2 * atan2(sqrt(a), sqrt(1 - a))
R <- 6371
d <- R * c
return(d)
}
long.stn1 <- -87.933
lat.stn1 <- 41.995
long.stn2 <- -87.752
lat.stn2 <- 41.786
train[, "DisStn1"] <- earth.dist(train$Longitude, train$Latitude,
                                 rep(long.stn1, nrow(train)),
                                 rep(lat.stn1, nrow(train)))
train[, "DisStn2"] <- earth.dist(train$Longitude, train$Latitude,
                                 rep(long.stn2, nrow(train)),
                                 rep(lat.stn2, nrow(train)))
test[, "DisStn1"] <- earth.dist(test$Longitude, test$Latitude,
                                 rep(long.stn1, nrow(test)),
                                 rep(lat.stn1, nrow(test)))
test[, "DisStn2"] <- earth.dist(test$Longitude, test$Latitude,
                                 rep(long.stn2, nrow(test)),
                                 rep(lat.stn2, nrow(test)))
train[, "ClosestStn"] <- ifelse(train$DisStn1 < train$DisStn2, 1, 2)
test[, "ClosestStn"] <- ifelse(test$DisStn1 < test$DisStn2, 1, 2)
summary(train[,19:21])
```

```
##     DisStn1         DisStn2          ClosestStn
##  Min.   : 4.14   Min.   : 0.8572   Min.   :1.000
##  1st Qu.:17.77   1st Qu.:10.3361   1st Qu.:1.000
##  Median :26.17   Median :14.4021   Median :2.000
##  Mean   :26.96   Mean   :14.6058   Mean   :1.709
##  3rd Qu.:37.49   3rd Qu.:19.1911   3rd Qu.:2.000
##  Max.   :49.62   Max.   :26.2772   Max.   :2.000
```

```
summary(test[,19:21])
```

```
##     DisStn1         DisStn2          ClosestStn
##  Min.   : 4.14   Min.   : 0.8572   Min.   :1.000
```

```
##  1st Qu.:17.27   1st Qu.:10.3297   1st Qu.:1.000
##  Median :26.15   Median :15.3222   Median :2.000
##  Mean   :26.72   Mean   :14.7680   Mean   :1.696
##  3rd Qu.:36.21   3rd Qu.:19.5879   3rd Qu.:2.000
##  Max.   :50.42   Max.   :26.2772   Max.   :2.000
```

Save this data set

```
write.csv(train, "../data/train2B.csv", row.names=F)
write.csv(test, "../data/test2B.csv", row.names=F)
```

Data Exploration

The distribution of blocks

It seems like the distribution of blocks does not have a very regular sequence.

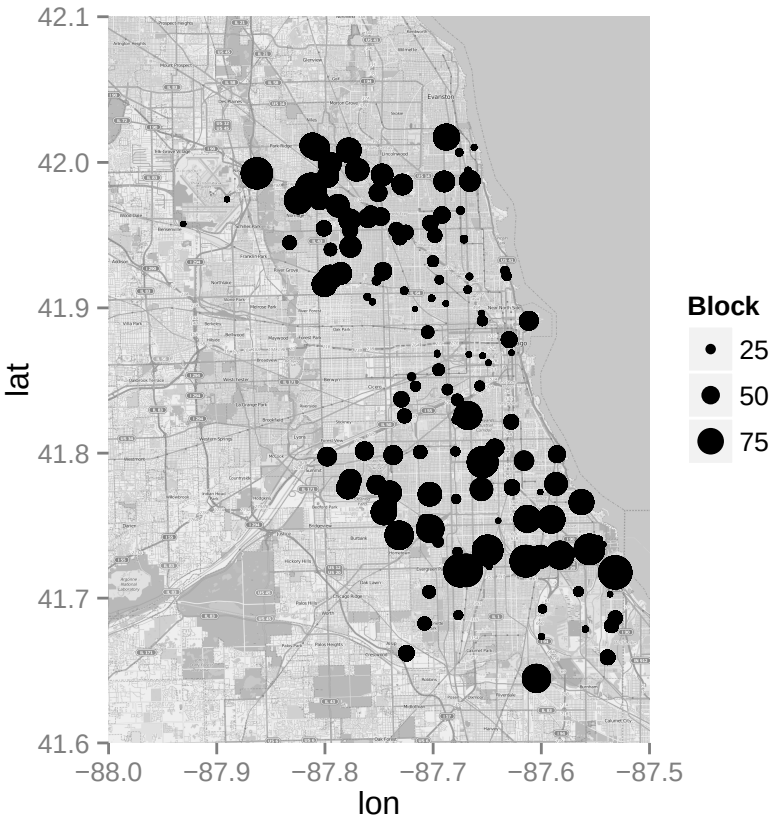
```
library(ggplot2)
```

```
## Use suppressPackageStartupMessages to eliminate package startup messages.
```

```
library(ggmap)
```

```
## Google Maps API Terms of Service: http://developers.google.com/maps/terms.
## Please cite ggmap if you use it: see citation('ggmap') for details.
```

```
mapdata <- readRDS("../data/mapdata_copyright_openstreetmap_contributors.rds")
ggmap(mapdata) + geom_point(data=train, aes(x=Longitude,y=Latitude, size=Block))
```


42.1
42.0
41.9
41.8
41.7
41.6
lat
−88.0
−87.9
−87.8
−87.7
−87.6
−87.5
lon
Block
25
50
75