In [43]:
```
require(readr)
library(reshape2)
library(ggmap)
stations <- read_tsv('~/Google\ Drive/Laurier/BU\ 425/project/citibike
_stations_2017.csv.zip')
```

```
Parsed with column specification:
cols(
  dock_id = col_integer(),
  dock_name = col_character(),
  date = col_character(),
  hour = col_integer(),
  minute = col_integer(),
  pm = col_integer(),
  avail_bikes = col_integer(),
  avail_docks = col_integer(),
  tot_docks = col_integer(),
  `_lat` = col_double(),
  `_long` = col_double(),
  in_service = col_integer(),
  status_key = col_integer()
)
```

In [26]:
```
head(stations[stations$hour == 12,])
```

dock_id	dock_name	date	hour	minute	pm	avail_bikes	avail_docks	tot_docks	_lat
72	W 52 St & 11 Ave	17-01-01	12	1	0	25	12	39	40.7
72	W 52 St & 11 Ave	17-01-01	12	8	1	21	16	39	40.7
72	W 52 St & 11 Ave	17-01-02	12	39	0	27	10	39	40.7
72	W 52 St & 11 Ave	17-01-02	12	41	1	32	5	39	40.7
72	W 52 St & 11 Ave	17-01-03	12	34	1	37	2	39	40.7
72	W 52 St & 11 Ave	17-01-04	12	28	0	34	5	39	40.7

In [28]:

```
nrow(stations)
```

5350485

I'm interested in knowing how the availability of the bikes changes over the course of a day. To do this, I'll first compute the percentage of available bikes and transform the hour into 24-hour time.

In [29]:

```
stations['avail_bikes_percent'] = stations['avail_bikes'] / stations['
tot_docks']
stations$hour[stations$pm == 1 & stations$hour != 12] <- stations$hour
[stations$pm == 1 & stations$hour != 12] + 12 # Use 24 hour time
stations$hour[stations$pm == 0 & stations$hour == 12] <- stations$hour
[stations$pm == 0 & stations$hour == 12] + 12 # Use 24 hour time
stations$avail_bikes_percent[is.na(stations$avail_bikes_percent)] <- 0
stations_subset <- subset(stations, select=c('dock_id', 'dock_name', "
date", "hour", 'avail_bikes_percent'))
```

Next, I will transform the dataset into a wide format: adding 24 columns for each hour of the day.

In [30]:
```
avail_by_hour <- dcast(stations_subset, dock_id + dock_name + date ~ hour, mean, fill=0)
```

```
Using avail_bikes_percent as value column: use value.var to override
.
```

In [31]:
```
head(avail_by_hour)
```

dock_id	dock_name	date	1	2	3	4	5	6
72	W 52 St & 11 Ave	17-01-01	0.6666667	0.6666667	0.6666667	0.6666667	0.6666667	0.6
72	W 52 St & 11 Ave	17-01-02	0.7179487	0.7435897	0.7435897	0.0000000	0.7179487	0.7
72	W 52 St & 11 Ave	17-01-03	0.9230769	0.9230769	0.9230769	0.9230769	0.8974359	0.9
72	W 52 St & 11 Ave	17-01-04	0.8717949	0.8717949	0.8717949	0.8461538	0.8205128	0.0
72	W 52 St & 11 Ave	17-01-05	0.3589744	0.3589744	0.3589744	0.3846154	0.3846154	0.4
72	W 52 St & 11 Ave	17-01-06	0.1794872	0.2307692	0.2307692	0.2307692	0.2307692	0.2

In [33]:
```
nrow(avail_by_hour)
```

191313

Next to reduce the size of the dataset, each station and average each hour together. Thereby producing the average hourly availability per station.

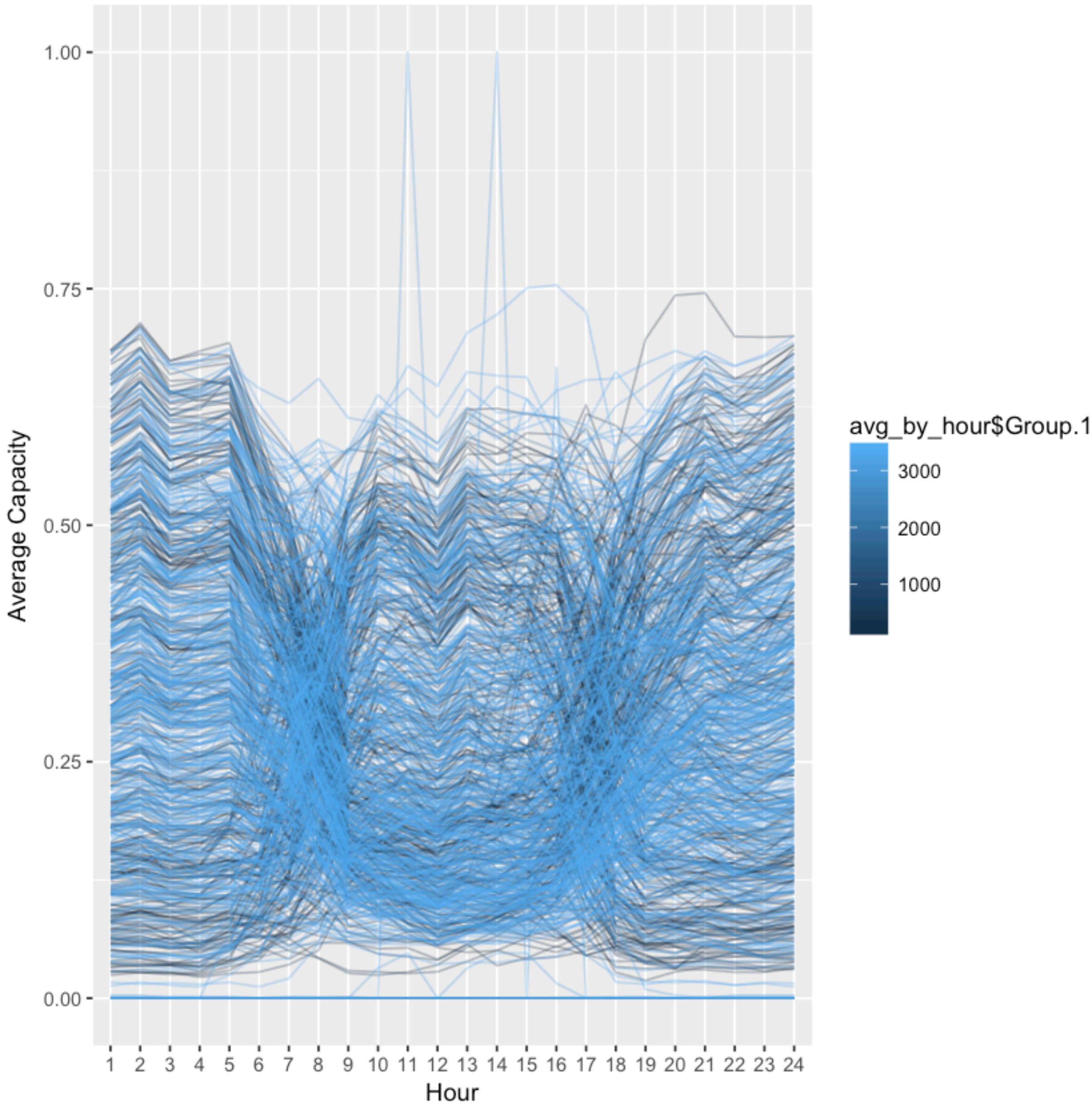
In [34]:
```
library(ggplot2)
melted_by_hour <- melt(avail_by_hour, id.vars=c("dock_id", "dock_name"
, "date"))
avg_by_hour <- aggregate(melted_by_hour$value, list(melted_by_hour$doc
k_id, melted_by_hour$variable), mean, na.rm=TRUE)
head(avg_by_hour)
```

Group.1	Group.2	x
72	1	0.2949163
79	1	0.1832912
82	1	0.3271605
83	1	0.3233647
116	1	0.1929309
119	1	0.4652517

In [35]:
```
nrow(avg_by_hour)
```

16992

In [7]:
```
ggplot(avg_by_hour, aes(x=avg_by_hour$Group.2, y=avg_by_hour$x, group=
avg_by_hour$Group.1, color=avg_by_hour$Group.1)) +
    geom_line(alpha=0.3) +
    xlab("Hour") +
    ylab("Average Capacity")
```



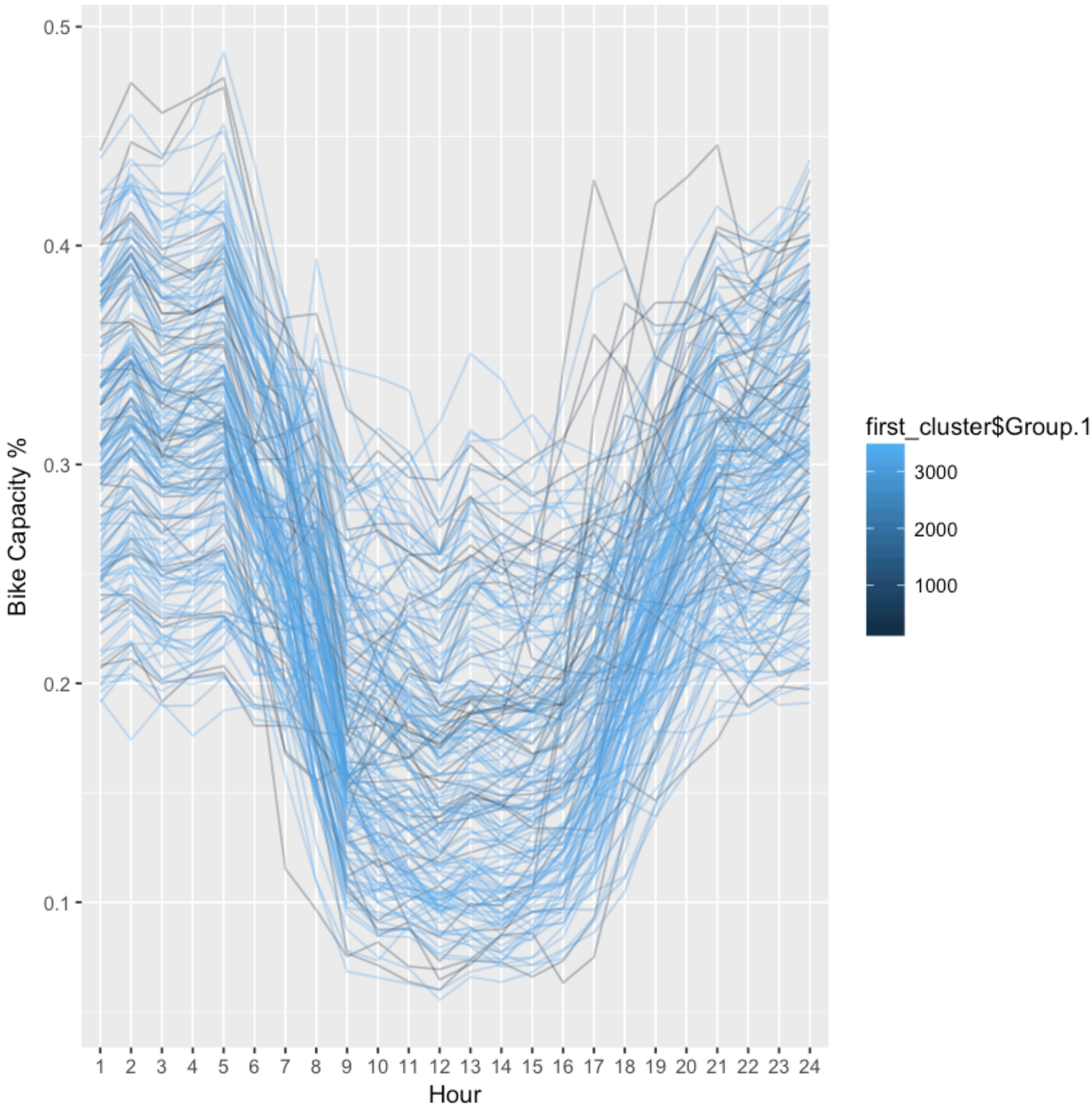
To attempt to separate the data, I am utilizing a k-means clustering algorithm. After experimenting with the number of clusters, I found that 6 clusters produced the best separation (note that I will later merge these clusters into 3 clusters).

Note that running the clustering may change which stations are assigned to each cluster, meaning the numbering may be different, but the contents of the clusters should be the same.

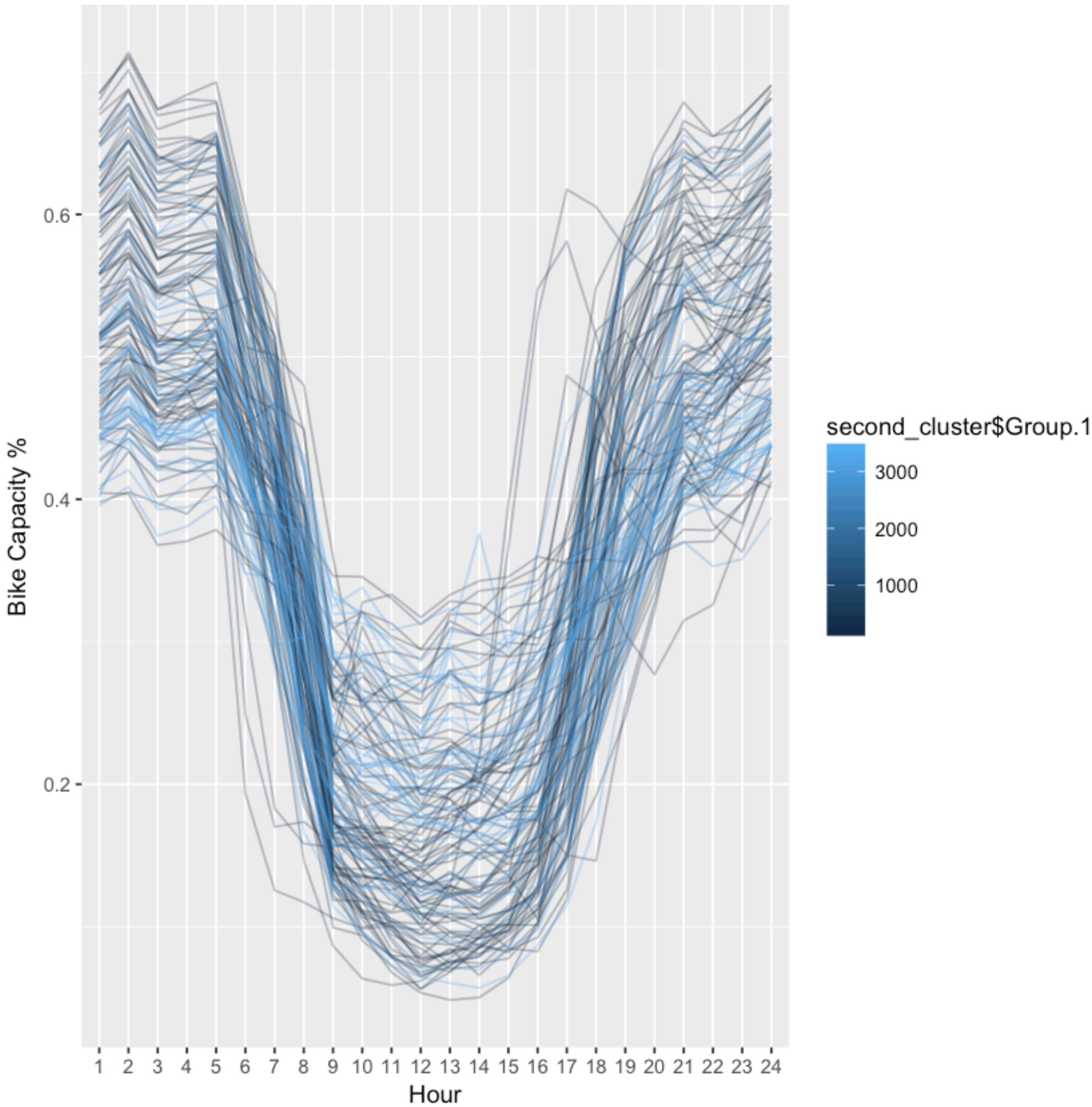
In [38]:
```
test <- avg_by_hour
test$x[is.na(test$x)] = 0
dtest <- dcast(test, Group.1 ~ Group.2)

clusters <- kmeans(subset(dtest, select=-c(Group.1)), 6, iter.max=20,
algorithm='MacQueen')
summary(clusters)

out <- cbind(dtest, clusterNum = clusters$cluster)
first_cluster = melt(subset(out[out$clusterNum == 1,], select=-c(clust
erNum)), id.vars='Group.1')
second_cluster = melt(subset(out[out$clusterNum == 2,], select=-c(clus
terNum)), id.vars='Group.1')
third_cluster = melt(subset(out[out$clusterNum == 3,], select=-c(clust
erNum)), id.vars='Group.1')
fourth_cluster = melt(subset(out[out$clusterNum == 4,], select=-c(clus
terNum)), id.vars='Group.1')
fifth_cluster = melt(subset(out[out$clusterNum == 5,], select=-c(clust
erNum)), id.vars='Group.1')
sixth_cluster = melt(subset(out[out$clusterNum == 6,], select=-c(clust
erNum)), id.vars='Group.1')
```

```
Using x as value column: use value.var to override.

             Length Class  Mode
cluster      708    -none- numeric
centers      144    -none- numeric
totss          1    -none- numeric
withinss       6    -none- numeric
tot.withinss   1    -none- numeric
betweenss      1    -none- numeric
size           6    -none- numeric
iter           1    -none- numeric
ifault         0    -none- NULL
```

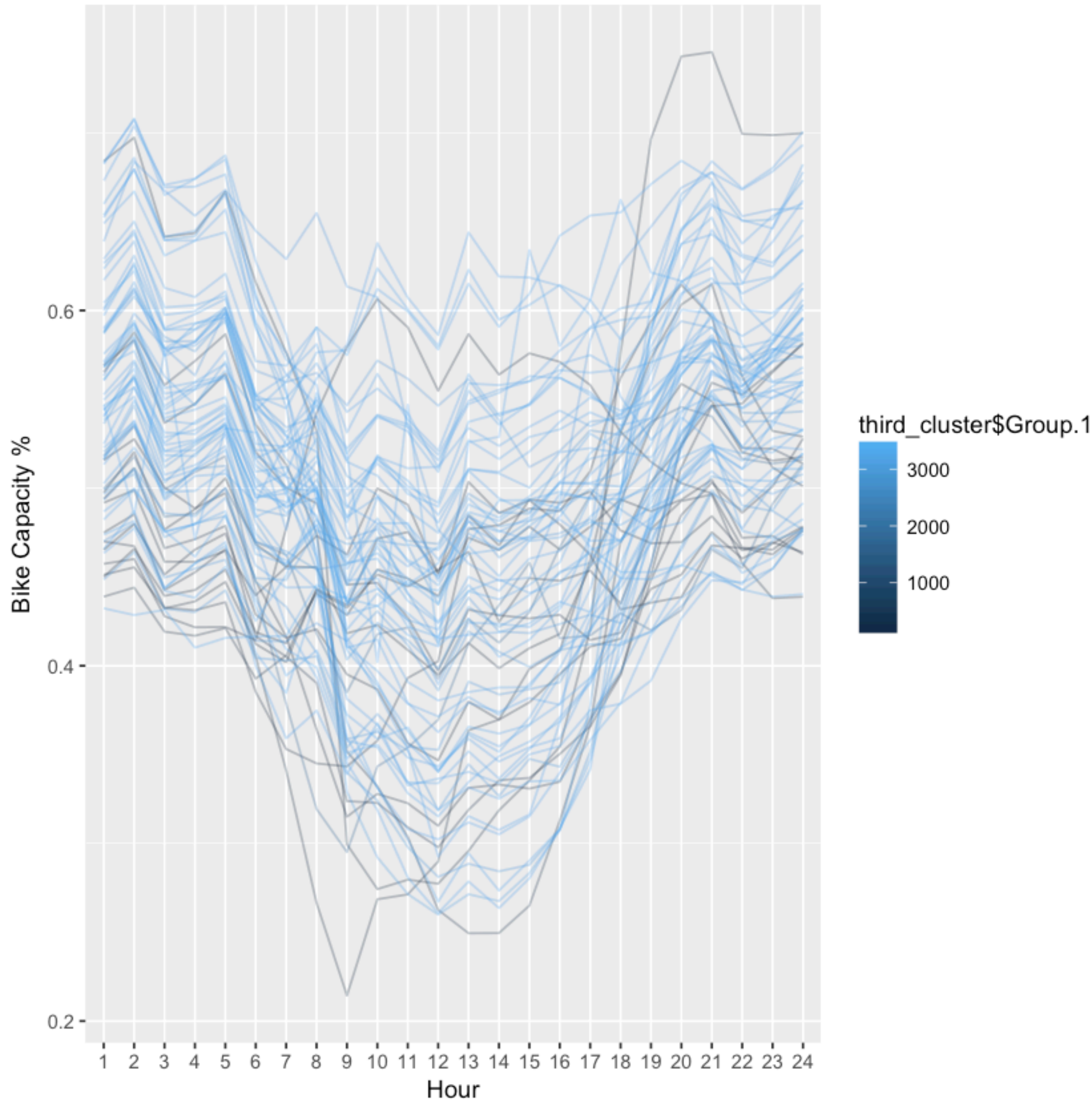
In [40]:
```
ggplot(first_cluster, aes(x=first_cluster$variable, y=first_cluster$va
lue, group=first_cluster$Group.1, color=first_cluster$Group.1)) +
    geom_line(alpha=0.3) +
    xlab("Hour") +
    ylab("Bike Capacity %")
ggplot(second_cluster, aes(x=second_cluster$variable, y=second_cluster
$value, group=second_cluster$Group.1, color=second_cluster$Group.1)) +
    geom_line(alpha=0.3) +
    xlab("Hour") +
    ylab("Bike Capacity %")
ggplot(third_cluster, aes(x=third_cluster$variable, y=third_cluster$va
lue, group=third_cluster$Group.1, color=third_cluster$Group.1)) +
    geom_line(alpha=0.3) +
    xlab("Hour") +
    ylab("Bike Capacity %")
```



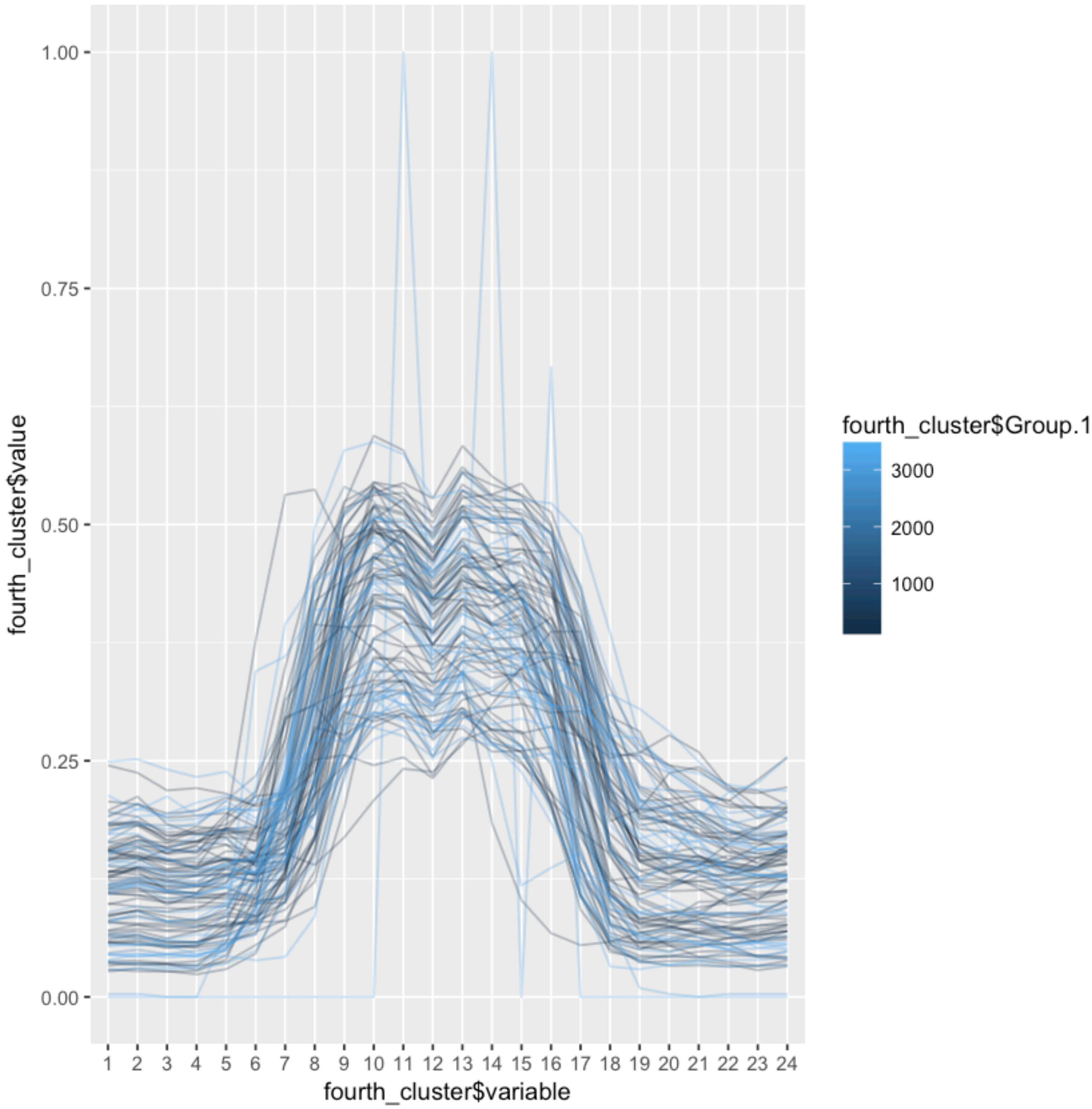
0.5
0.4
0.3
0.2
0.1
Bike Capacity %
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
first_cluster$Group.1
3000
2000
1000



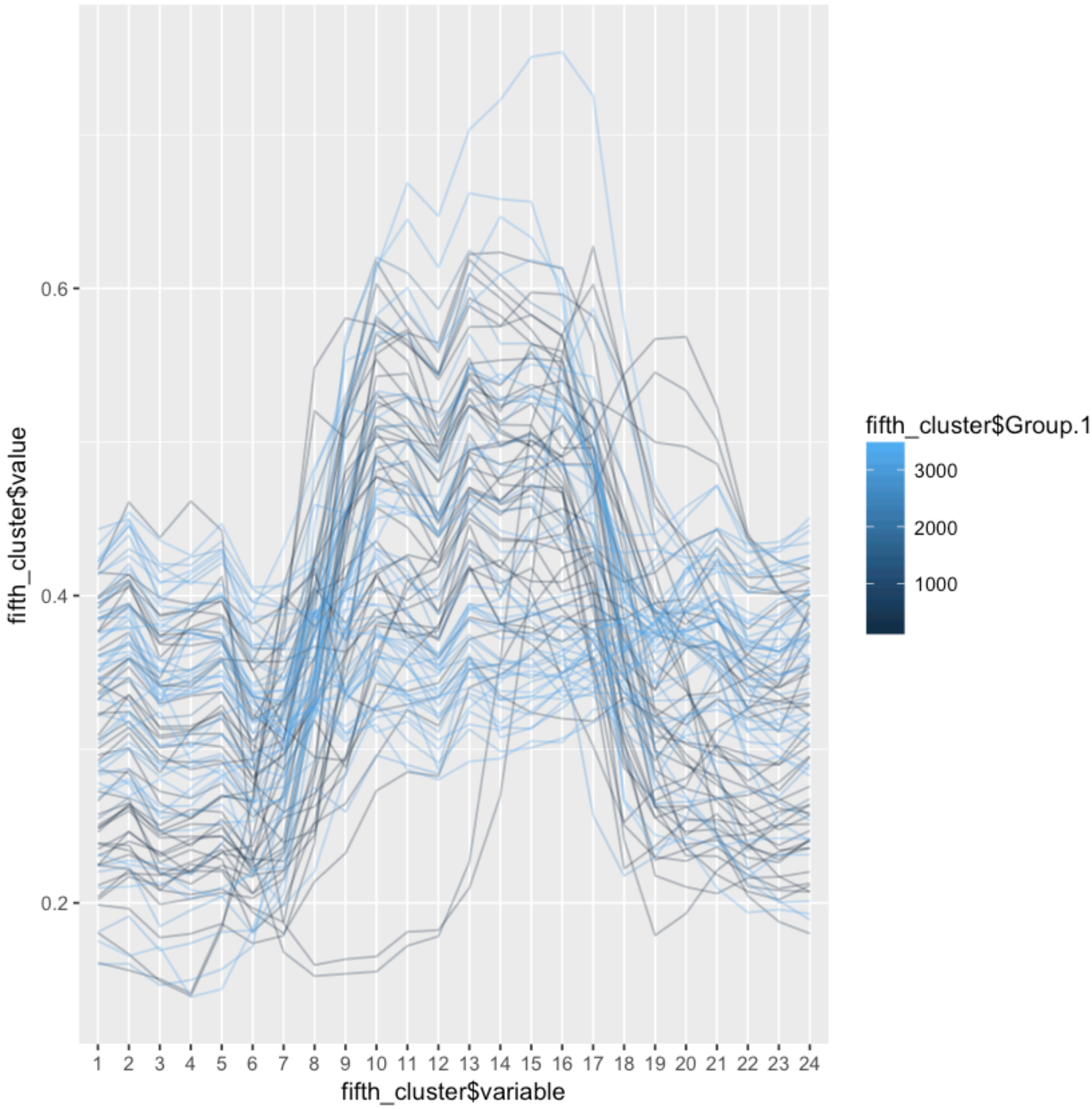
0.6
0.4
0.2
Bike Capacity %
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
second_cluster$Group.1
3000
2000
1000

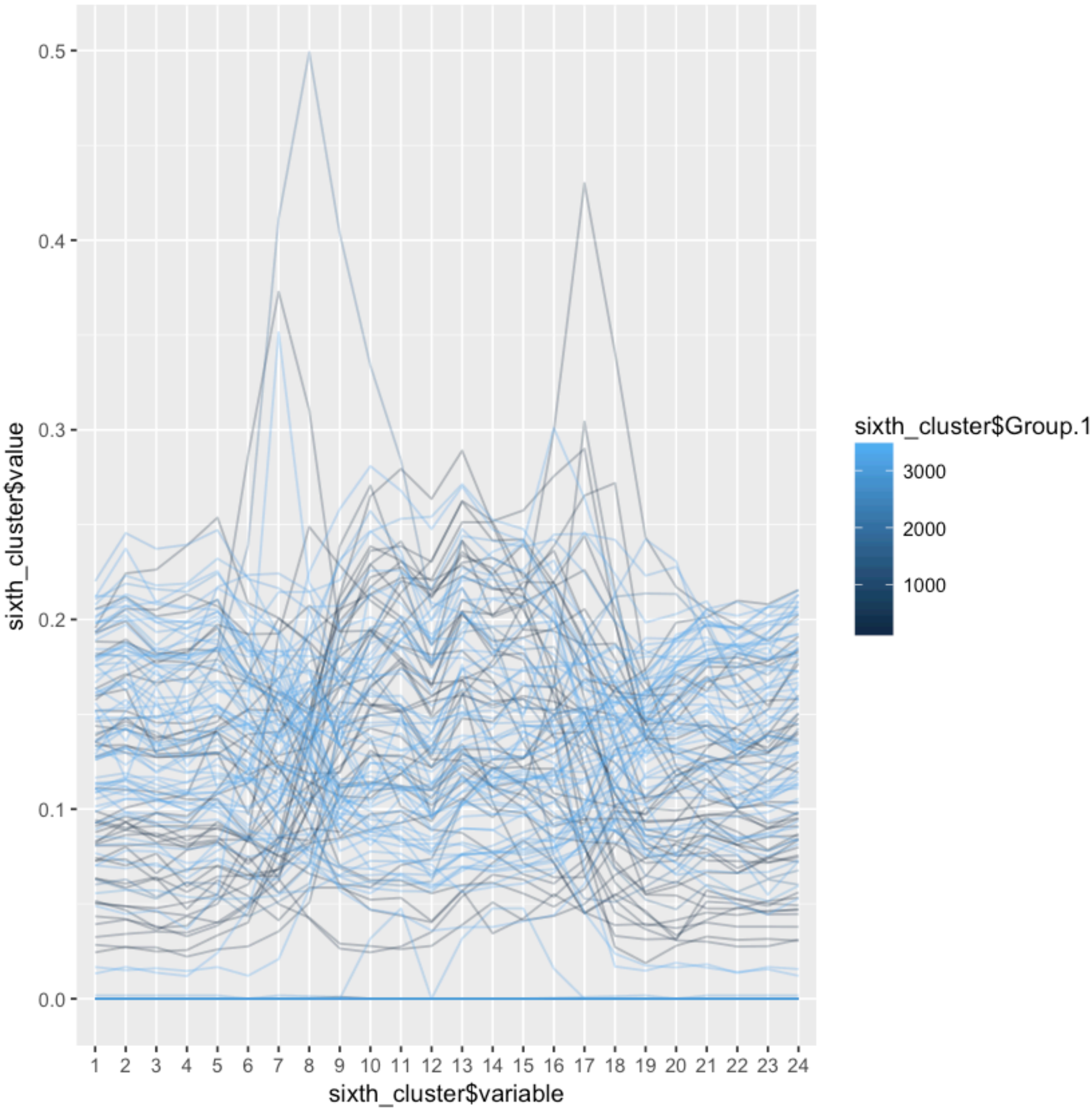


In [41]:
```
ggplot(fourth_cluster, aes(x=fourth_cluster$variable, y=fourth_cluster
$value, group=fourth_cluster$Group.1, color=fourth_cluster$Group.1)) +
    geom_line(alpha=0.3)
ggplot(fifth_cluster, aes(x=fifth_cluster$variable, y=fifth_cluster$va
lue, group=fifth_cluster$Group.1, color=fifth_cluster$Group.1)) +
    geom_line(alpha=0.3)
ggplot(sixth_cluster, aes(x=sixth_cluster$variable, y=sixth_cluster$va
lue, group=sixth_cluster$Group.1, color=sixth_cluster$Group.1)) +
    geom_line(alpha=0.3)
```



1.00
0.75
0.50
0.25
0.00
fourth_cluster$value
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
fourth_cluster$variable
fourth_cluster$Group.1
3000
2000
1000


fifth_cluster$value
0.6
0.4
0.2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
fifth_cluster$variable
fifth_cluster$Group.1
3000
2000
1000


0.5
0.4
0.3
0.2
0.1
0.0
sixth_cluster$value
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
sixth_cluster$variable
sixth_cluster$Group.1
3000
2000
1000

In [42]:
```
cluster_one_stations <- unique(subset(stations[stations$dock_id %in%
first_cluster$Group.1,], select=c("dock_id", "dock_name", "_lat", "_lo
ng", 'hour', 'avail_bikes_percent')))
cluster_two_stations <- unique(subset(stations[stations$dock_id %in%
second_cluster$Group.1,], select=c("dock_id", "dock_name", "_lat", "_l
ong", 'hour', 'avail_bikes_percent')))
cluster_three_stations <- unique(subset(stations[stations$dock_id %in%
third_cluster$Group.1,], select=c("dock_id", "dock_name", "_lat", "_lo
ng", 'hour', 'avail_bikes_percent')))
cluster_four_stations <- unique(subset(stations[stations$dock_id %in%
fourth_cluster$Group.1,], select=c("dock_id", "dock_name", "_lat", "_l
ong", 'hour', 'avail_bikes_percent')))
cluster_five_stations <- unique(subset(stations[stations$dock_id %in%
fifth_cluster$Group.1,], select=c("dock_id", "dock_name", "_lat", "_lo
ng", 'hour', 'avail_bikes_percent')))
cluster_six_stations <- unique(subset(stations[stations$dock_id %in%
sixth_cluster$Group.1,], select=c("dock_id", "dock_name", "_lat", "_lo
ng", 'hour', 'avail_bikes_percent')))
```

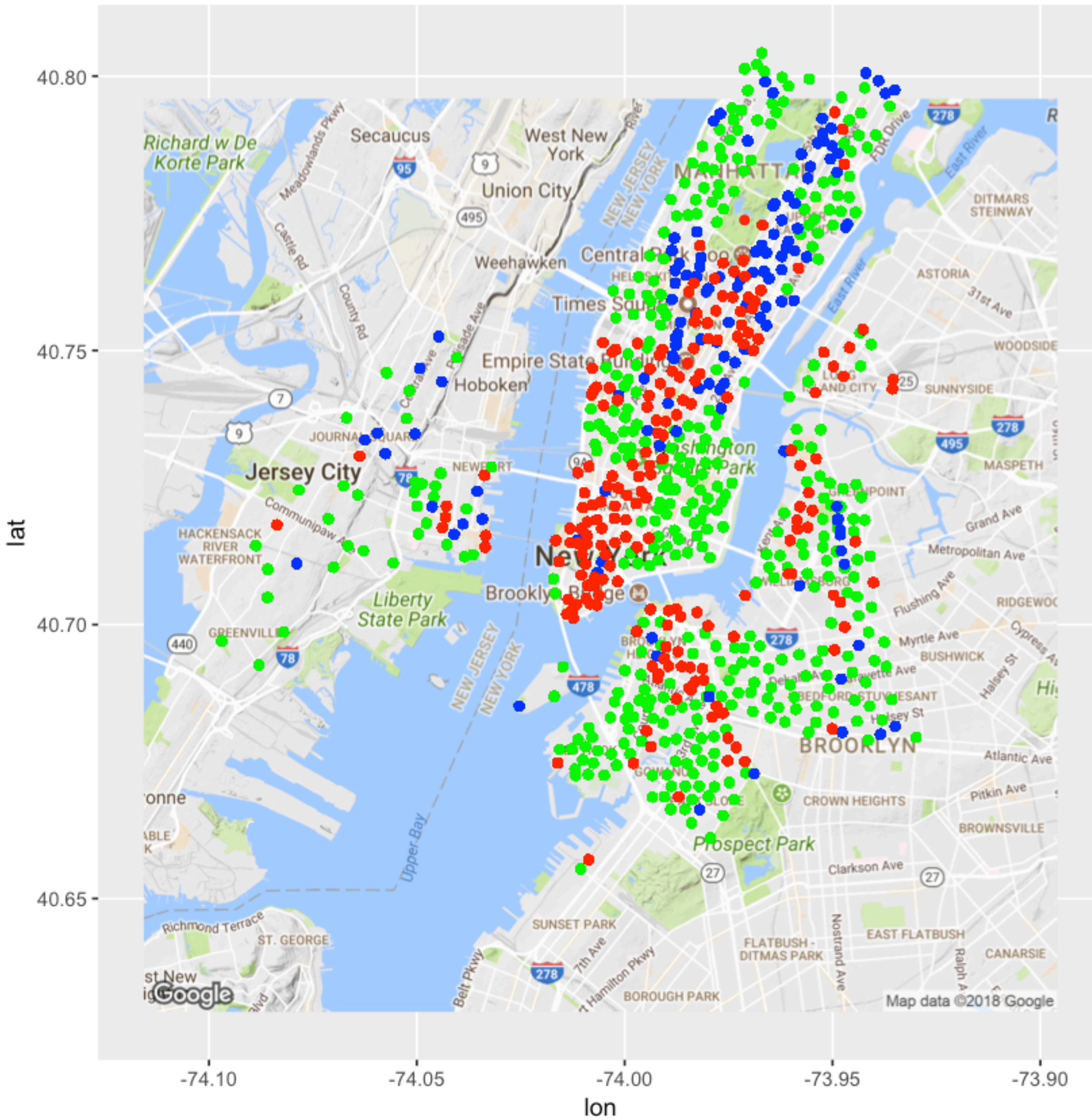
From the graphs above:

- It is clear that clusters one, two, and three have a large demand for bikes in the morning (around 8am) and the evening (around 6pm) experiences an increase supply of bikes. Meaning this would correlate with individuals commuting to work from their homes.
- Clusters four and five also exhibits a clear pattern of an increased supply of bikes arriving in the morning and an increased demand for bikes in the evening. Meaning that this cluster likely is located near work places, and these shifts in demand represent commuters arriving on their way to work.
- Clusters 6 experienced mostly constant demand. This is likely be an artifact of the averaging techniques used.

In [46]:
```
residential <- rbind(cluster_one_stations, cluster_two_stations,
cluster_three_stations)
work <- rbind(cluster_four_stations, cluster_five_stations)
low <- rbind(cluster_six_stations)
```

In [47]:
```
NYC_map = ggmap(get_googlemap(center=as.numeric(geocode("New York")),
scale=2, zoom=12), extent="normal")
NYC_map +
    geom_point(aes(x=residential["_long"], y=residential["_lat"]),
data=residential, col="green", alpha=0.4) +
    geom_point(aes(x=low["_long"], y=low["_lat"]), data=low, alpha=0.4
, col="blue") +
    geom_point(aes(x=work["_long"], y=work["_lat"]), data=work, alpha=
0.4, col='red')
```

```
Information from URL : http://maps.googleapis.com/maps/api/geocode/j
son?address=New%20York&sensor=false
Map from URL : http://maps.googleapis.com/maps/api/staticmap?center=
40.712775,-74.005973&zoom=12&size=640x640&scale=2&maptype=terrain&se
nsor=false
```



Plotting these clusters on a map of New York City seems to confirm my hypothesis in terms of geographic location. The "work" cluster largely is located in the financial district, near where many people work. While the "residential" cluster is located where people live, in the East Village and Brooklyn.

In [48]:
```
write.csv(low, file='low_cluster.csv')
write.csv(residential, file='residential_cluster.csv')
write.csv(cluster_five_stations, file='work_cluster.csv')
```