Assignment 6: Multivariate Data Mining

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Objective Statement:

Methods:

The function `is.na()` is the 'Not Available' function, which checks the dataframe to see where those elements are missing. Prepending the `!` operator to `is.na()` causes the function to return the element indeces that do in fact contain the value or characters placed in the 'Not Available' function. Thus, in this instance, we search for `HGM_TYPE` and create a new dataframe that only contains the rows that contain a a recorded hydrogeomorphic type.

We now add new columns to the newly created dataframe that are slightly more meaninful and easily discerned:

```
# Suggested additions
mdwhgm$area.sqkm = mdwhgm[,"Shape_Area"]/1000000 # m^2 to km^2
mdwhgm$catch.sqkm = mdwhgm[,"CATCHMENT_"]/1000000# m^2 to km^2
mdwhgm$elev_m = mdwhgm[,"ELEV_MEAN"]
mdwhgm$elev_r = mdwhgm[,"ELEV_RANGE"]
mdwhgm$lat_dd = mdwhgm[,"LAT_DD"]
mdwhgm$lon_dd = mdwhgm[,"LONG_DD"]
mdwhgm$slope.pct = mdwhgm[,"FLOW_SLOPE"]
mdwhgm$edge.comp = mdwhgm[,"EDGE_COMPL"]
mdwhgm$clay = mdwhgm[,"ClayTot_r"]
mdwhgm$soil.kf = mdwhgm[,"Kf"]

# Additional meaningful columns
```

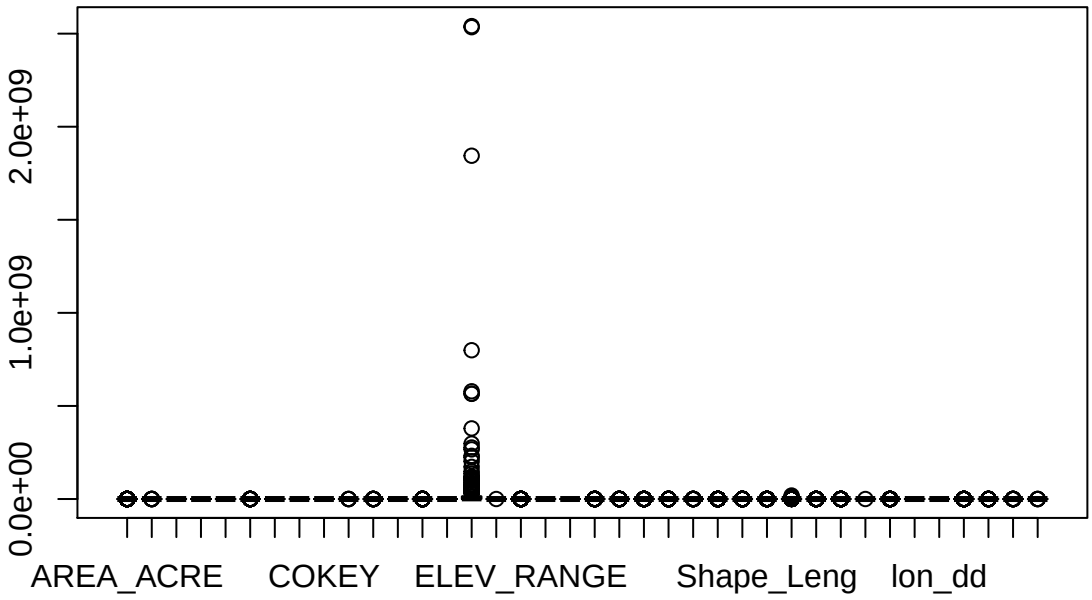
```
# EDA
summary(mdwhgm)
```

```
##    AREA_ACRE         STATE               ID               HUC12
##  Min.   :   1.004   CA:431   UCDSNM000008:  1   180201220204: 10
##  1st Qu.:   6.037   NV:  7   UCDSNM000010:  1   180400061101:  8
##  Median :  19.309            UCDSNM000012:  1   180400100501:  8
##  Mean   :  80.450            UCDSNM000015:  1   160501010301:  7
##  3rd Qu.:  52.124            UCDSNM000016:  1   160501010303:  6
##  Max.   :4610.374            UCDSNM000017:  1   180200030106:  6
##                              (Other)     :432   (Other)     :393
##                        OWNERSHIP     EDGE_COMPL
##  Lassen National Forest    : 60   Min.   :1.033
##  Sierra National Forest    : 58   1st Qu.:1.641
##  Inyo National Forest      : 56   Median :2.062
##  Private                   : 52   Mean   :2.340
##  Stanislaus National Forest: 40   3rd Qu.:2.658
##  Sequoia National Forest   : 35   Max.   :9.642
##  (Other)                   :137
##                DOM_ROCKTY                  VEG_MAJORI
##  granodiorite       :173   Riparian             :197
```

```
##  andesite           :154   Conifer              :195
##  glacial drift      : 40   Shrubland            : 32
##  alluvium           : 36   Hardwood             :  9
##  tephrite (basanite):  6   Barren-Rock/Sand/Clay:  2
##  argillite          :  5   Hardwood-Conifer     :  1
##  (Other)            : 24   (Other)              :  2
##              COKEY           Kf           ClayTot_r         MUKEY
##  470977:660084  : 15   Min.   :0.0000   Min.   : 1.00   470977 : 15
##  465178:642932  : 14   1st Qu.:0.2000   1st Qu.: 6.00   465178 : 14
##  464853:642321  : 12   Median :0.2400   Median :12.00   464853 : 12
##  1652104:1207250: 11   Mean   :0.2718   Mean   :12.06   1652104: 11
##  464983:642549  : 11   3rd Qu.:0.3200   3rd Qu.:15.00   464983 : 11
##  471192:666181  : 10   Max.   :0.5500   Max.   :50.00   471192 : 10
##  (Other)        :365                                    (Other):365
##    SOIL_SURVE            COMP_NAME     CATCHMENT_          ELEV_MEAN
##  SSURGO :379   Aquolls         : 23   Min.   :1.263e+03   Min.   : 742.3
##  STATSGO: 59   Monache variant: 21   1st Qu.:5.670e+05   1st Qu.:1728.9
##                Cagwin family  : 15   Median :3.350e+06   Median :2024.5
##                Toem           : 13   Mean   :3.732e+07   Mean   :2072.1
##                AQUEPTS        : 12   3rd Qu.:1.358e+07   3rd Qu.:2366.4
##                Tahoe          : 12   Max.   :2.540e+09   Max.   :3266.4
##                (Other)        :342
##    ELEV_RANGE           LAT_DD         LONG_DD         FLOW_RANGE
##  Min.   :  0.4037   Min.   :35.45   Min.   :-121.6   Min.   :    42.43
##  1st Qu.:  9.7699   1st Qu.:37.45   1st Qu.:-120.6   1st Qu.:  1388.75
##  Median : 19.9371   Median :38.78   Median :-120.1   Median :  3413.27
##  Mean   : 33.2681   Mean   :38.77   Mean   :-119.9   Mean   :  7160.09
##  3rd Qu.: 36.6473   3rd Qu.:40.23   3rd Qu.:-119.1   3rd Qu.:  7277.69
##  Max.   :359.3870   Max.   :41.98   Max.   :-118.1   Max.   :170870.00
##
##    FLOW_SLOPE          ED_MIN_LAK      ED_MIN_FLO        ED_MIN_SEE
##  Min.   :1.354e-05   Min.   :    0   Min.   :    0.0   Min.   :    0.0
##  1st Qu.:2.870e-03   1st Qu.: 1553   1st Qu.:    0.0   1st Qu.:  642.6
##  Median :7.199e-03   Median : 3535   Median :    0.0   Median : 2133.9
##  Mean   :1.278e-02   Mean   : 5514   Mean   :  928.9   Mean   : 2990.9
##  3rd Qu.:1.624e-02   3rd Qu.: 7190   3rd Qu.:  311.7   3rd Qu.: 4430.1
##  Max.   :1.456e-01   Max.   :32386   Max.   :29463.1   Max.   :15875.4
##
##                        HGM_TYPE     ED_MIN_FSt         Shape_Leng
##  Riparian low gradient     :181   Min.   :    0.00   Min.   :   242.4
##  Riparian middle gradient  : 72   1st Qu.:    0.00   1st Qu.:   991.6
##  Subsurface low gradient   : 51   Median :    0.00   Median :  1947.2
##  Subsurface middle gradient: 35   Mean   :  196.42   Mean   :  4461.2
##  Discharge slope           : 24   3rd Qu.:   31.62   3rd Qu.:  4159.1
##  Depressional perennial    : 19   Max.   :15389.20   Max.   :147644.1
##  (Other)                   : 56
##    Shape_Area         area.sqkm           catch.sqkm
##  Min.   :    4063   Min.   : 0.004063   Min.   :   0.0013
##  1st Qu.:   24432   1st Qu.: 0.024432   1st Qu.:   0.5670
##  Median :   78142   Median : 0.078142   Median :   3.3498
##  Mean   :  325573   Mean   : 0.325573   Mean   :  37.3219
##  3rd Qu.:  210937   3rd Qu.: 0.210937   3rd Qu.:  13.5770
##  Max.   :18657598   Max.   :18.657598   Max.   :2540.4858
##
```

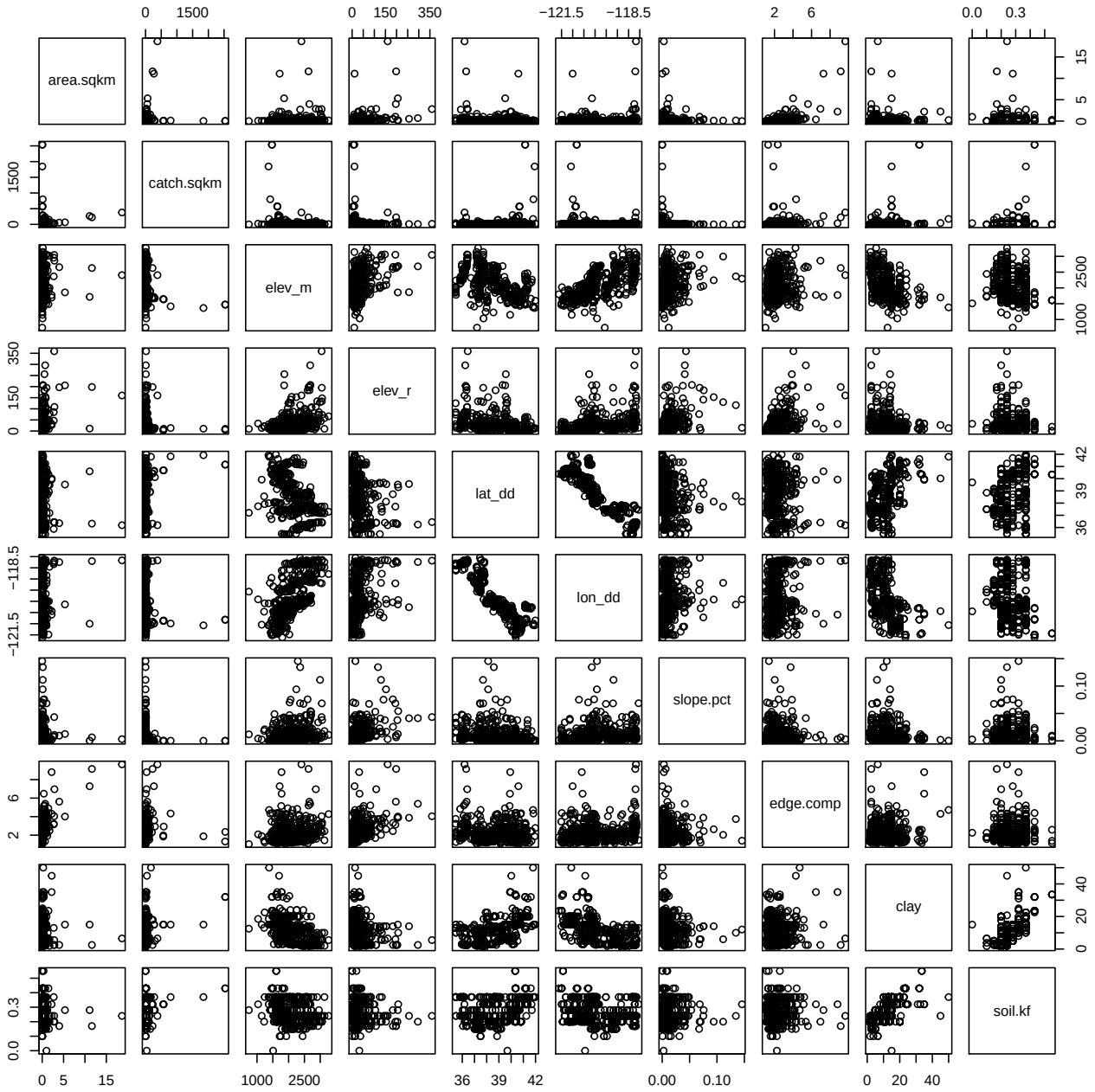
```
##      elev_m           elev_r            lat_dd          lon_dd
##  Min.   : 742.3   Min.   :  0.4037   Min.   :35.45   Min.   :-121.6
##  1st Qu.:1728.9   1st Qu.:  9.7699   1st Qu.:37.45   1st Qu.:-120.6
##  Median :2024.5   Median : 19.9371   Median :38.78   Median :-120.1
##  Mean   :2072.1   Mean   : 33.2681   Mean   :38.77   Mean   :-119.9
##  3rd Qu.:2366.4   3rd Qu.: 36.6473   3rd Qu.:40.23   3rd Qu.:-119.1
##  Max.   :3266.4   Max.   :359.3870   Max.   :41.98   Max.   :-118.1
##
##    slope.pct           edge.comp          clay          soil.kf
##  Min.   :1.354e-05   Min.   :1.033   Min.   : 1.00   Min.   :0.0000
##  1st Qu.:2.870e-03   1st Qu.:1.641   1st Qu.: 6.00   1st Qu.:0.2000
##  Median :7.199e-03   Median :2.062   Median :12.00   Median :0.2400
##  Mean   :1.278e-02   Mean   :2.340   Mean   :12.06   Mean   :0.2718
##  3rd Qu.:1.624e-02   3rd Qu.:2.658   3rd Qu.:15.00   3rd Qu.:0.3200
##  Max.   :1.456e-01   Max.   :9.642   Max.   :50.00   Max.   :0.5500
##
```

```r
boxplot(mdwhgm)
```




```r
#Optional method for keeping track of the relevant variables
rel_cols = c("area.sqkm", "catch.sqkm", "elev_m", "elev_r", "lat_dd", "lon_dd", "slope.pct", "edge.comp

rmdwhgm <-mdwhgm[,rel_cols]
```

```r
plot(rmdwhgm)
```



Most Variability: Elev Mean & Lat Soil Lat Lon Elev mean

Correlated: Soil & Clay Lat & Clay Lat & Elev Mean elev mean & Lon Edge & Elev Range Elev Mean & Lon Elev Mean & Clay

Step 2 - Clustering and Clustering Output

```
# Heirarchical Clustering
#dist using euclidean
plot.new()
rmdwhgm.dist<- dist(x = rmdwhgm[,rel_cols],method = "euclidean") #hclust using ward.D
rmdwhgm.hc<- hclust(rmdwhgm.dist,method="ward.D")
rect.hclust(rmdwhgm.hc,k=6)
```

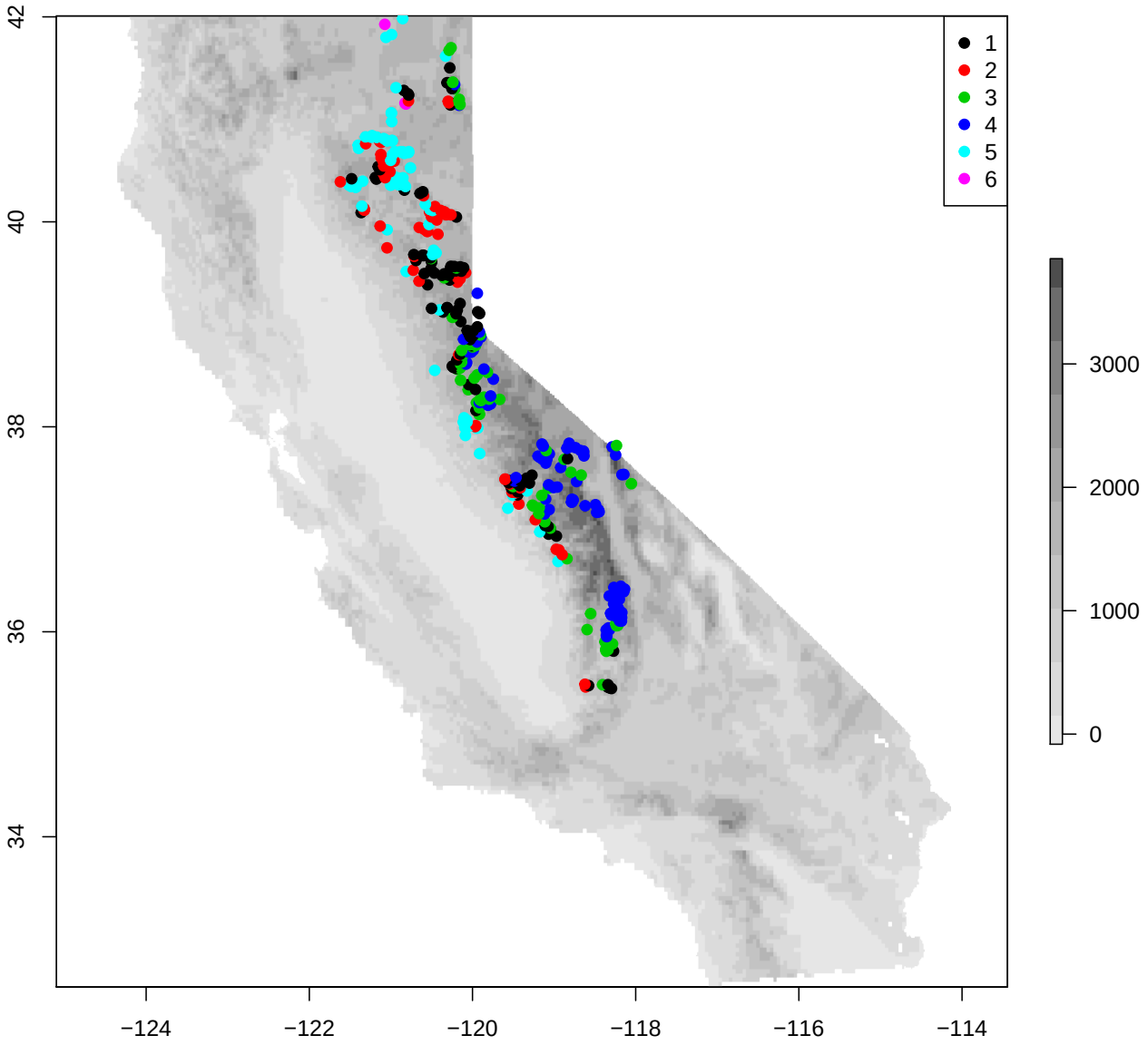
```
# k-means Clustering
rmdwhgm$hc6 <- cutree(rmdwhgm.hc, k=6) #store group # in hc6
rmdwhgm.km6 <- kmeans(rmdwhgm[,rel_cols],centers = 6)
rmdwhgm$km6 <- rmdwhgm.km6$cluster #store group # in km6
table(rmdwhgm$hc6, rmdwhgm$km6)
```

```
##
##       1   2   3   4   5   6
##   1   0   0   0   2 103   0
##   2   0  60   0   0  12   0
##   3   0   0   0  69   0   0
##   4   0   0  72   4   0  23
##   5   0  90   0   0   0   0
##   6   3   0   0   0   0   0
```

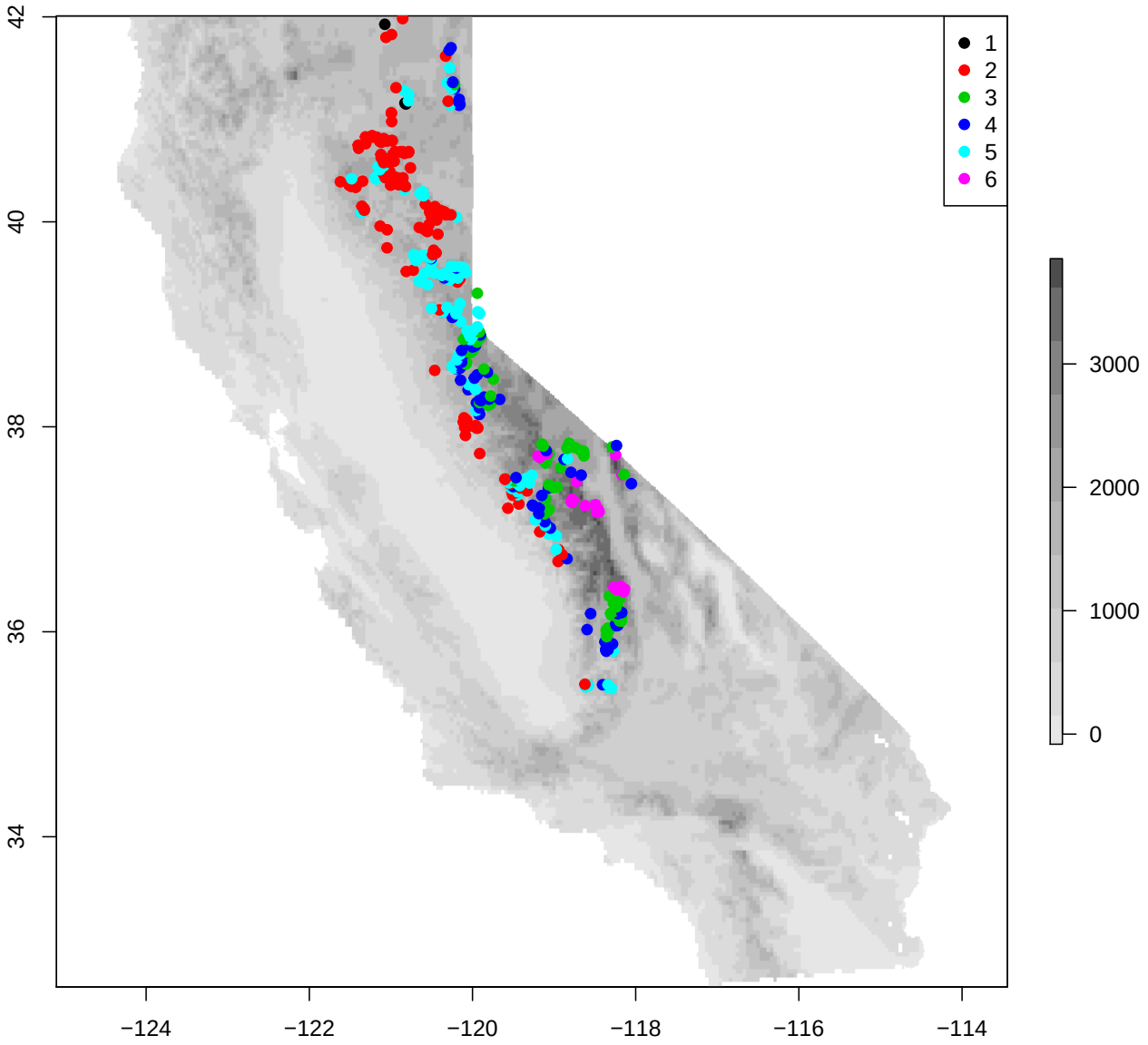
```
# Load the DEM
gdal_grid = readGDAL("DEM.tif")
```

```
## DEM.tif has GDAL driver GTiff
## and has 1137 rows and 1233 columns
```

```
dem = raster(gdal_grid) #use data as a projected raster
plot(dem,col=gray.colors(10, start=0.9, end=0.3))

# Create a vector to aid in plotting text for ProjLoc$ProjCode
xtext = rmdwhgm$lon_dd
ytext = rmdwhgm$lat_dd

# Plot the ProjLoc over the DEM
points(rmdwhgm$lon_dd,rmdwhgm$lat_dd,pch=19,col=rmdwhgm$hc6)
legend("topright",legend=levels(as.factor(rmdwhgm$hc6)),col=1:length(rmdwhgm$hc6),pch=19)
```




```
plot(dem,col=gray.colors(10, start=0.9, end=0.3))

# Create a vector to aid in plotting text for ProjLoc$ProjCode
xtext = rmdwhgm$lon_dd
ytext = rmdwhgm$lat_dd

# Plot the ProjLoc over the DEM
points(rmdwhgm$lon_dd,rmdwhgm$lat_dd,pch=19,col=rmdwhgm$km6)
legend("topright",legend=levels(as.factor(rmdwhgm$km6)),col=1:length(rmdwhgm$km6),pch=19)
```

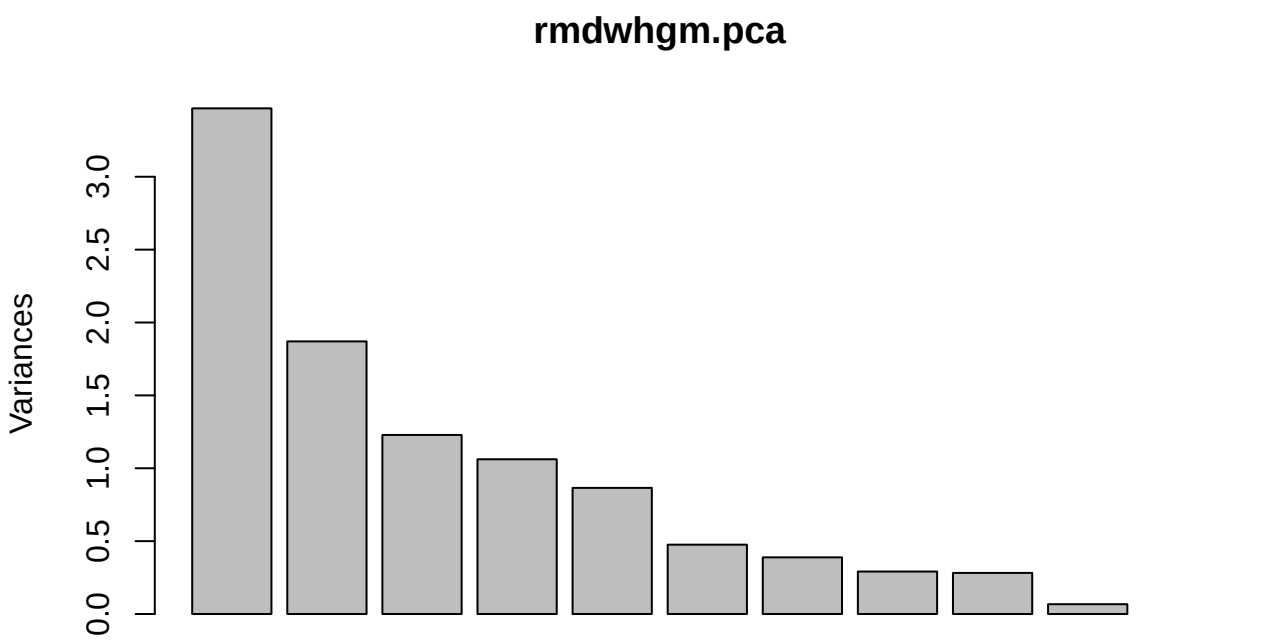


Step 3 - Principal Components Analysis (PCA)

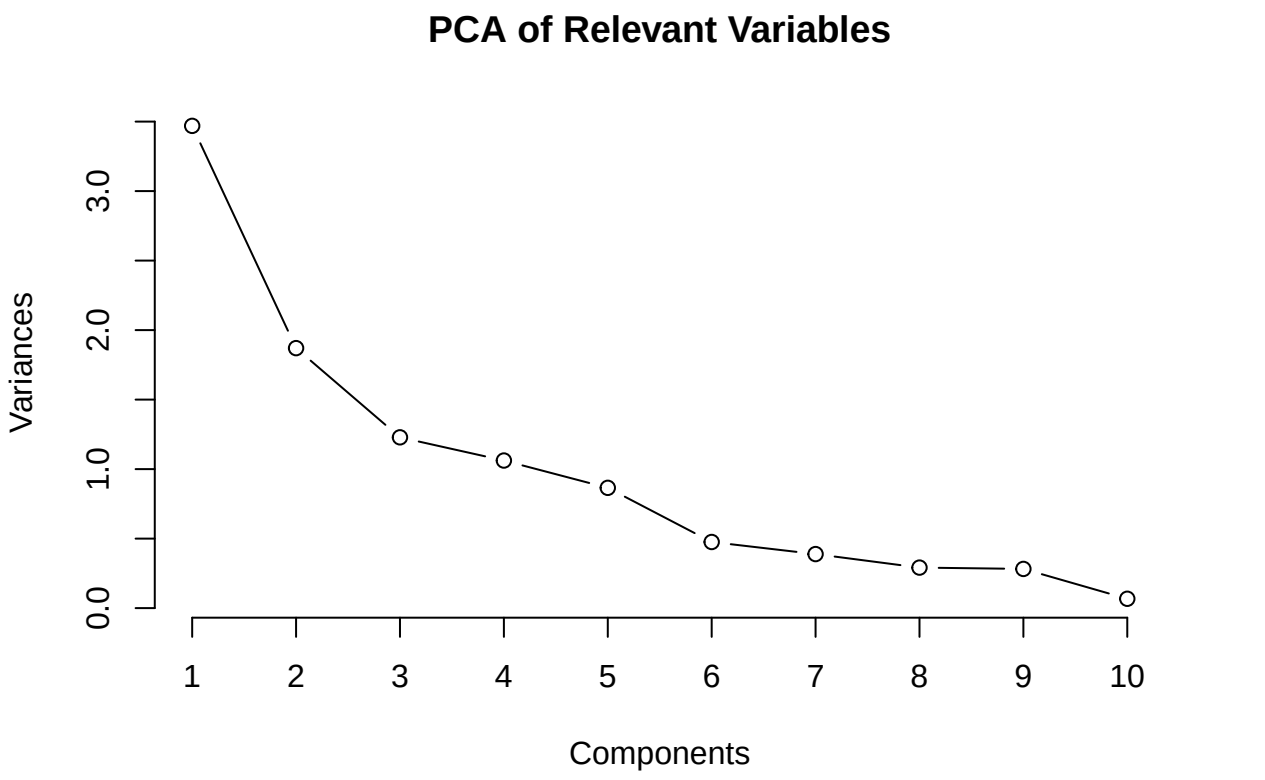
```
rmdwhgm.pca <- prcomp(x = rmdwhgm[,rel_cols], scale=TRUE, retx = TRUE, center = TRUE, scores=TRUE)

summary(rmdwhgm.pca)
```

```
## Importance of components:
##                           PC1   PC2    PC3    PC4     PC5     PC6     PC7
## Standard deviation     1.8626 1.368 1.1084 1.0303 0.93022 0.68970 0.62348
## Proportion of Variance 0.3469 0.187 0.1229 0.1062 0.08653 0.04757 0.03887
## Cumulative Proportion  0.3469 0.534 0.6568 0.7630 0.84950 0.89707 0.93594
##                            PC8     PC9    PC10
## Standard deviation     0.53982 0.53098 0.25931
## Proportion of Variance 0.02914 0.02819 0.00672
## Cumulative Proportion  0.96508 0.99328 1.00000
```

```r
screeplot(rmdwhgm.pca)
```




```r
plot(rmdwhgm.pca, type="lines", main="PCA of Relevant Variables")
title(xlab="Components")
```




```r
print(rmdwhgm.pca$rotation)
```

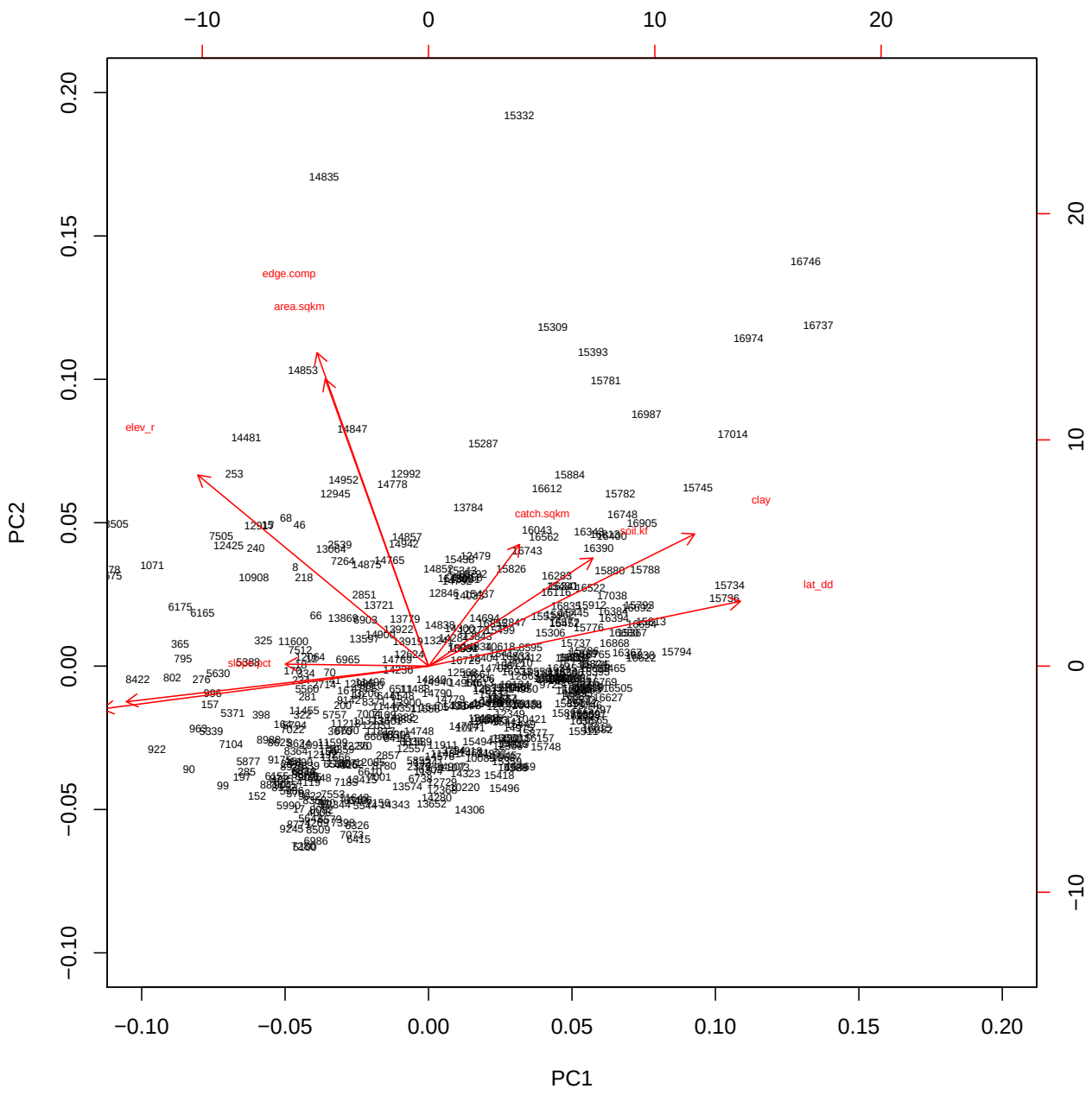
```
##                  PC1         PC2         PC3         PC4         PC5
```

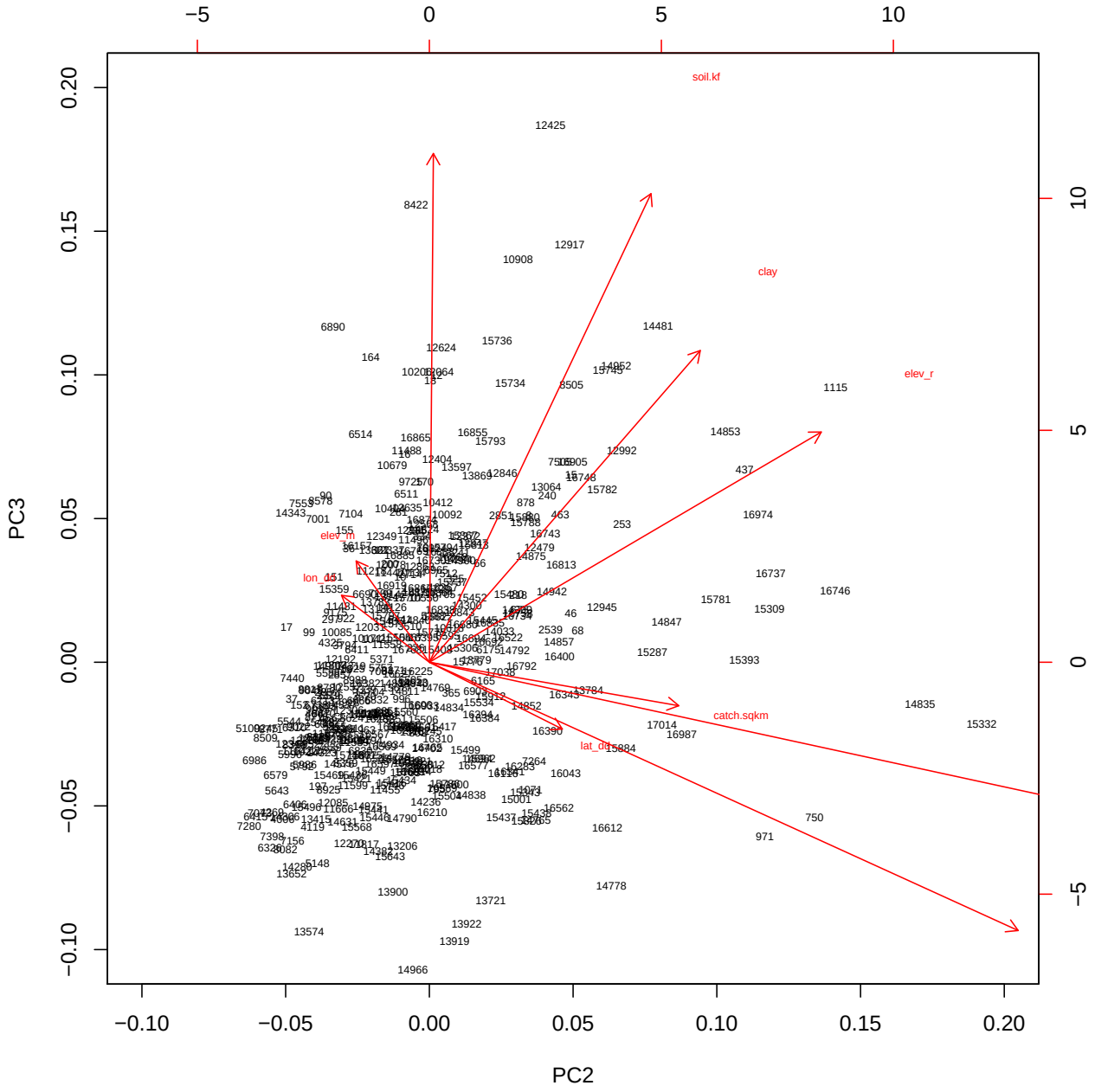
```
## area.sqkm  -0.1462876  0.554159722 -0.31168141  0.006739313 -0.11940625
## catch.sqkm  0.1289898  0.234746951 -0.05051764 -0.440247563  0.85288162
## elev_m     -0.4282282 -0.068885333  0.11763352 -0.130289127  0.01019772
## elev_r     -0.3269176  0.368857465  0.26743625  0.265512438  0.11165711
## lat_dd      0.4419842  0.125131661 -0.07763722  0.342372974  0.11382757
## lon_dd     -0.4623744 -0.082709361  0.07771838 -0.413325197 -0.08167852
## slope.pct  -0.2029250  0.003768749  0.59098183  0.467964316  0.30697839
## edge.comp  -0.1580674  0.604954813 -0.16185719  0.061295039 -0.15050199
## clay        0.3770195  0.254952226  0.36210215 -0.124183140 -0.19742971
## soil.kf     0.2329363  0.208604685  0.54433440 -0.438678067 -0.26508608
##                    PC6         PC7         PC8          PC9         PC10
## area.sqkm  -0.354512796  0.58937742 -0.18708568 -0.227863241  0.009518696
## catch.sqkm  0.002694082 -0.02418607  0.04156748 -0.005568175 -0.046123814
## elev_m      0.670616837  0.46281889  0.23312179 -0.109766969 -0.225023700
## elev_r      0.243243504 -0.40270320 -0.54906926 -0.280240829 -0.035121036
## lat_dd      0.455508457  0.23927745 -0.08212863  0.080459425  0.612232006
## lon_dd     -0.111527187 -0.10100697  0.06277639 -0.088017314  0.749327148
## slope.pct  -0.356495961  0.24965721  0.26777011  0.168070208  0.083395896
## edge.comp   0.130318470 -0.31719902  0.47670360  0.459956659 -0.005840521
## clay        0.002913792 -0.10417633  0.42817052 -0.642712041  0.008232692
## soil.kf     0.037577175  0.18554067 -0.33835653  0.436298489 -0.050367313
```

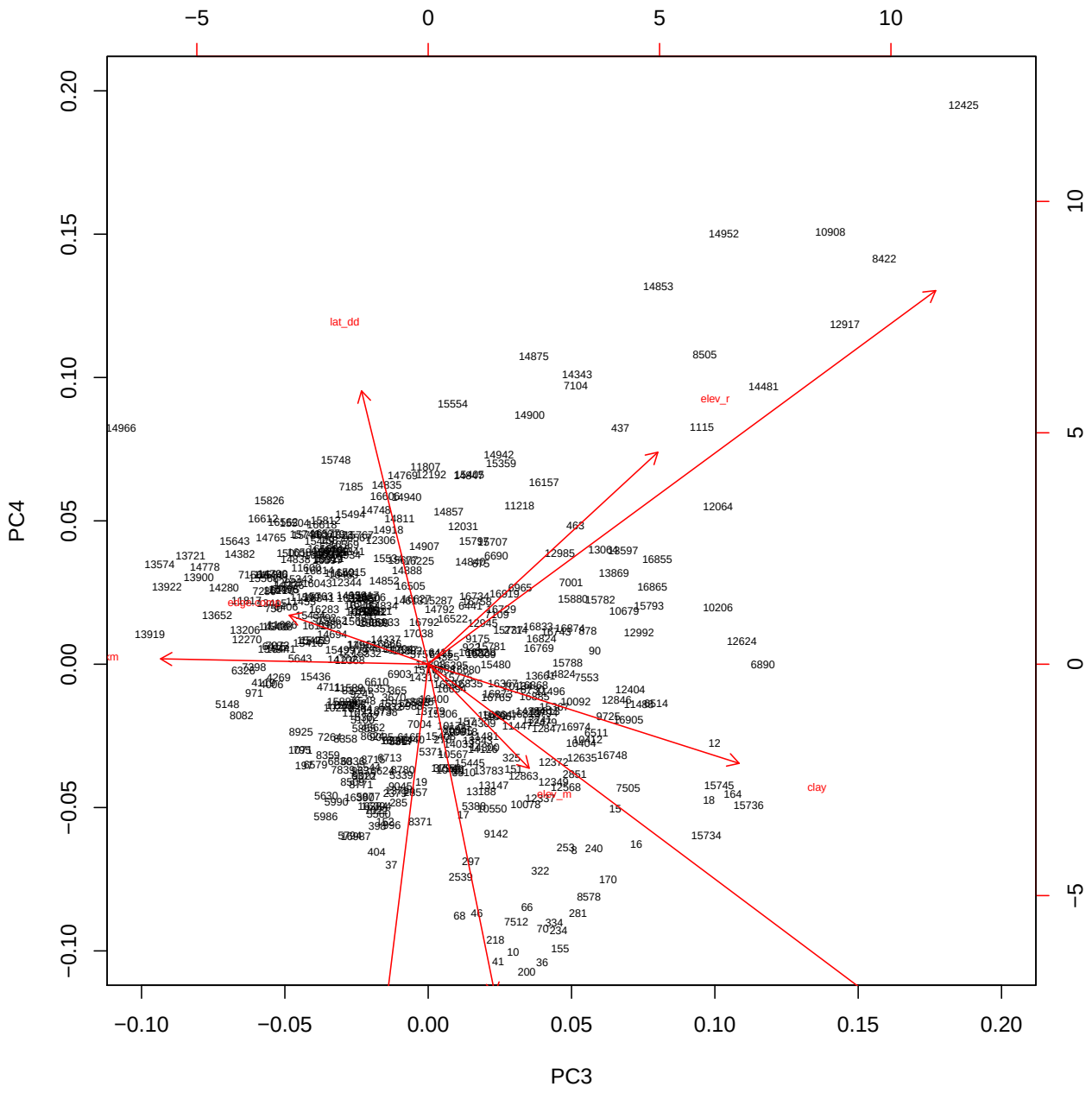
```
# Which parameters are driving the variability in the meadow dataset
# (i.e., highest value)? Are these positive or negative loadings?
```

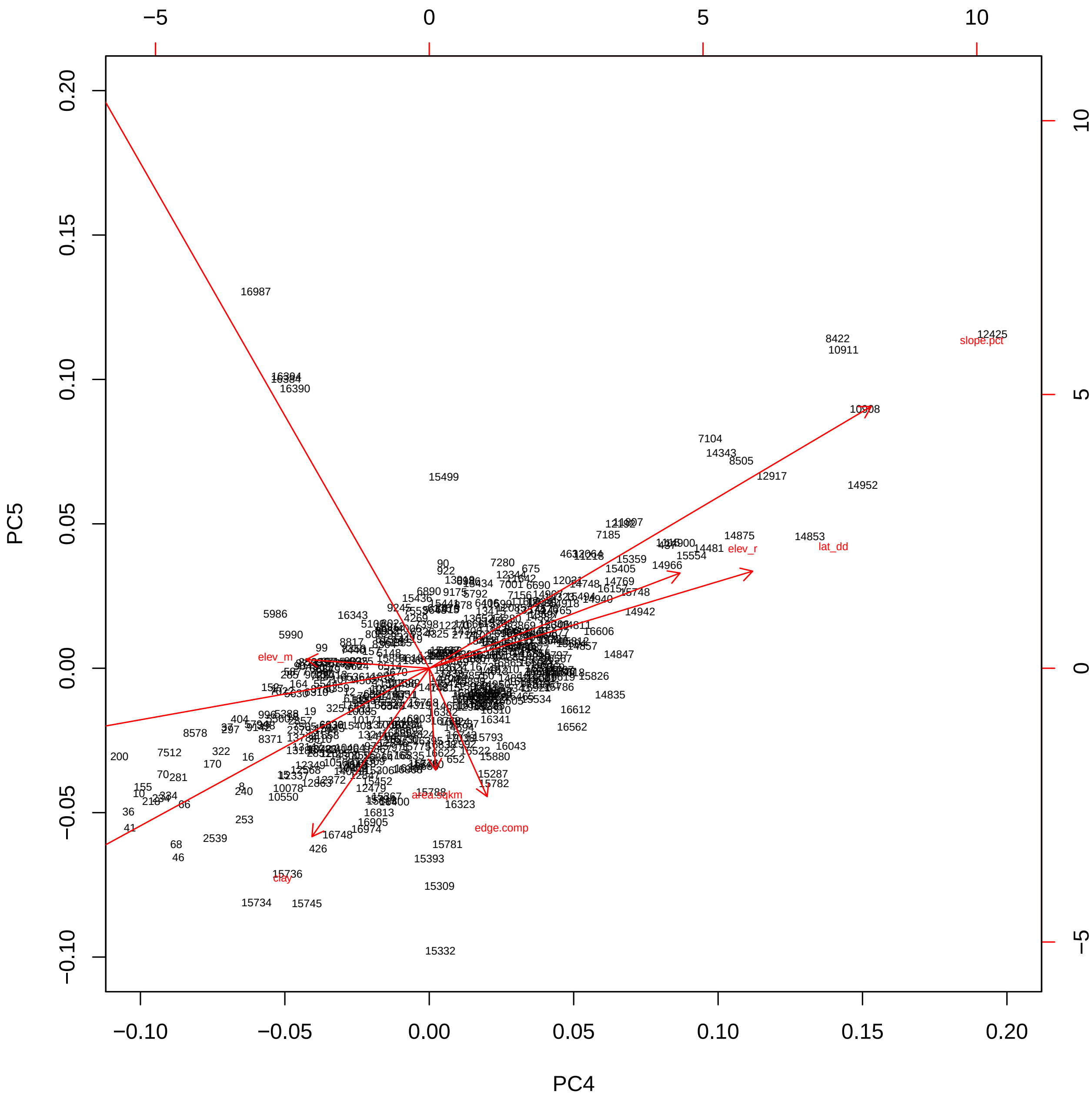
Driving the Loading: PC1: positive loading, driven by latitude, however, much negative loading is seen PC2: positive loading, edge complexity PC3: positive loading, slope percent PC4: positive loading, slope percent, negative loading, catch square km PC5: positive loading, catch square km

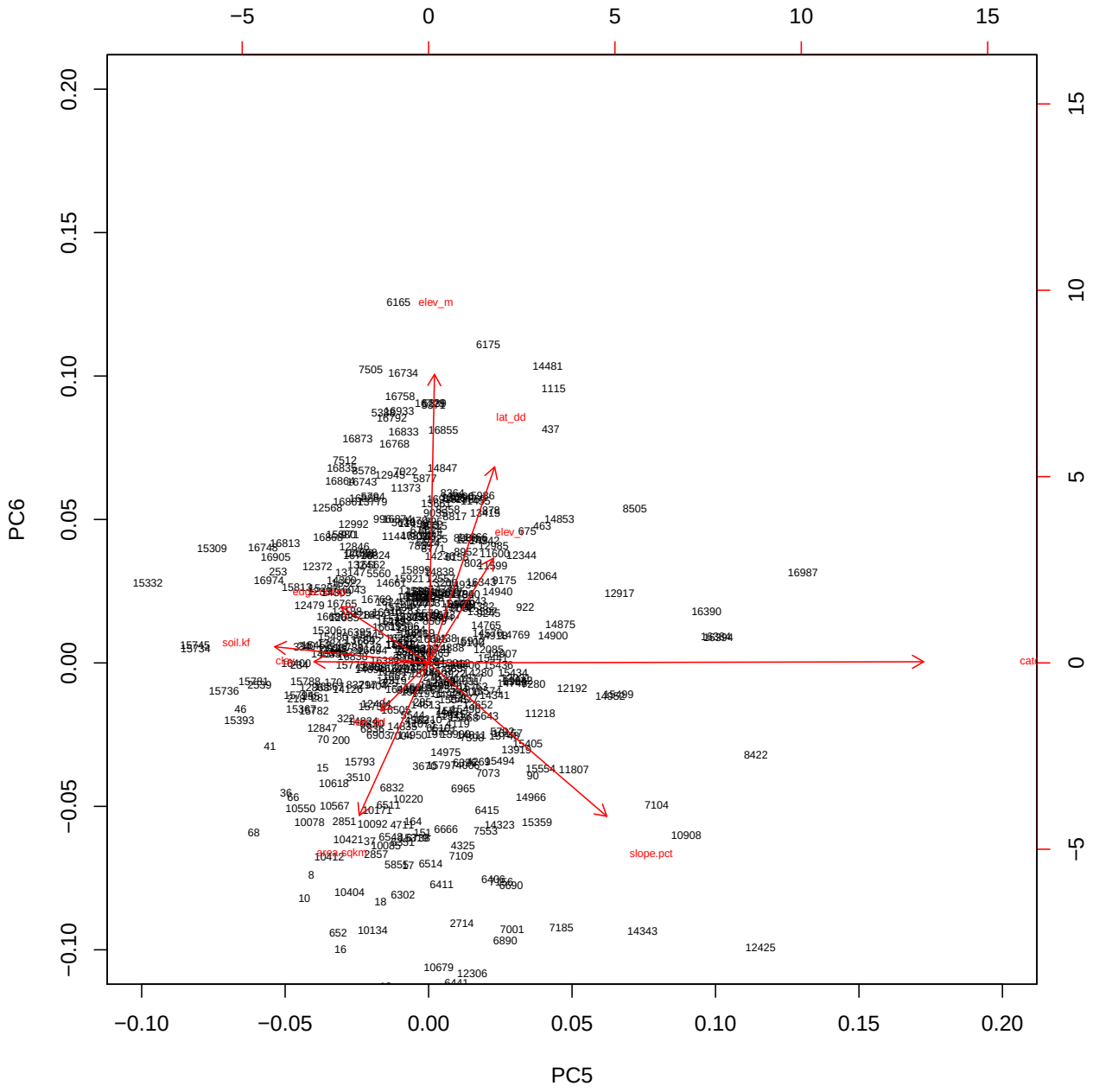
```
# Cycle throught the most important axes using a for loop, going from
# components 1 to 6
j<-1:5
for(i in j) {biplot(rmdwhgm.pca, choices=i:(i+1), cex=0.5, xlim=c(-0.1,0.2), ylim=c(- 0.1,0.2))}
```


edge.comp
area.sqkm
elev_r
slope_pct
catch.sqkm
soil.kf
clay
lat_dd
PC1
PC2

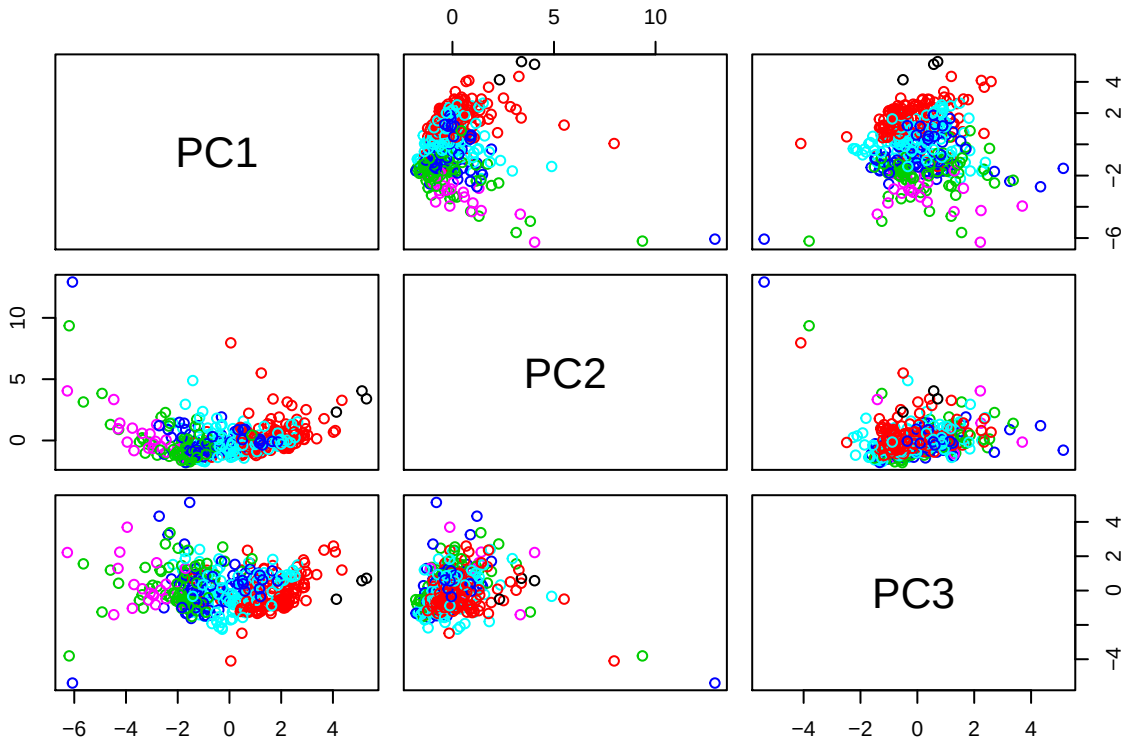

soil.kf
clay
elev_r
elev_m
lon_dd
lat_dd
catch.sqkm
PC2
PC3
−0.10
−0.05
0.00
0.05
0.10
0.15
0.20
−5
0
5
10


PC3
PC4
lat_dd
elev_r
clay
elev_m
−0.10
−0.05
0.00
0.05
0.10
0.15
0.20
−5
0
5
10

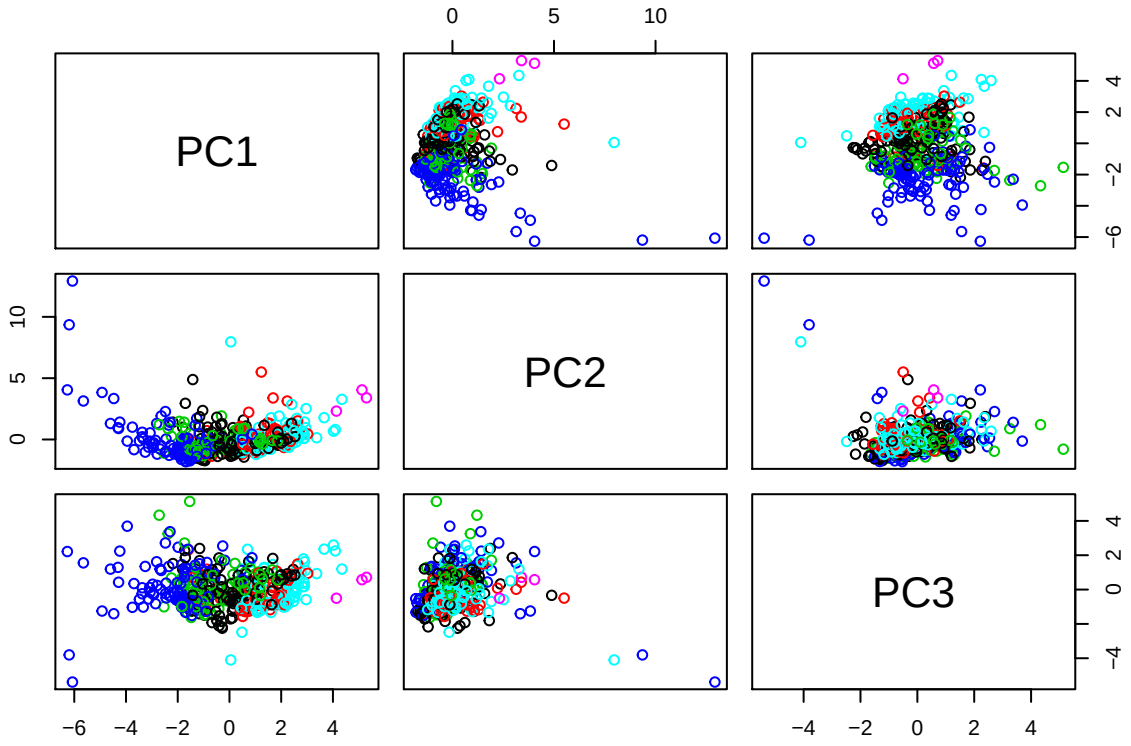

PC4
PC5
−0.10
−0.05
0.00
0.05
0.10
0.15
0.20
−5
0
5
10
slope.pct
lat_dd
elev_r
elev_m
area.sqkm
edge.comp
clay




```
pairs(rmdwhgm.pca$x[,1:3],col=rmdwhgm$km6)#colored by Kmeans group
```




```
pairs(rmdwhgm.pca$x[,1:3],col=rmdwhgm$hc6)#colored by HClust group
```



Step 4 - Contingency Analysis of Hydrogeomorphic Type

```
chisq.test(table(rmdwhgm$hc6, rmdwhgm$km6))
```

```
## Warning in chisq.test(table(rmdwhgm$hc6, rmdwhgm$km6)): Chi-squared
## approximation may be incorrect
```

```
##
##  Pearson's Chi-squared test
##
## data:  table(rmdwhgm$hc6, rmdwhgm$km6)
## X-squared = 1625.7, df = 25, p-value < 2.2e-16
```

```
# Does there appear to be relationship based on counts?
# Is there a statistical relationship?
```

Step 5 - Summarize the Data by National Forest