Clasificación de uso de suelo en Zapopan: estadisticas de signaturas

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language: output - spanish, code comments - english

```
verbose = 0

control_parcels_path <- "Control_zones.shp"
classification_path <- "../2016_classif/random/random_points_50000_buff100_dissok.shp"

raster_path <- "../2016_corrections/compose_LC80290462016_feb_mar_8PC_incl_b8.TIF"
raster_layers_names <- c("pc1","pc2","pc3","pc4","pc5","pc6","pc7","pc8")
raster_layers_count <- 8

class_codes <- c(100,101,103,105,110,115,120,130,135,150,155,160,161,190,192,195,197,200)
class_legend <- c("Urbano",
                  "Urbano disperso",
                  "Infraestructura",
                  "SVA",
                  "Agr. riego",
                  "Agr. temporal",
                  "Pastizal",
                  "Matorral",
                  "BEsp",
                  "BTC",
                  "BTSC",
                  "BTemp disp.",
                  "BTemp dens.",
                  "Golf",
                  "AVU",
                  "VAS",
                  "BGal",
                  "Agua")
```

```
# load zone shape
control_parcels <- readShapePoly(control_parcels_path)
# load classification
main_class <- readShapePoly(classification_path)

# load only the first layer of the source raster
raster_l1 <- raster(raster_path)
dim(raster_l1)
```

```
## [1] 3840 2618    1
```

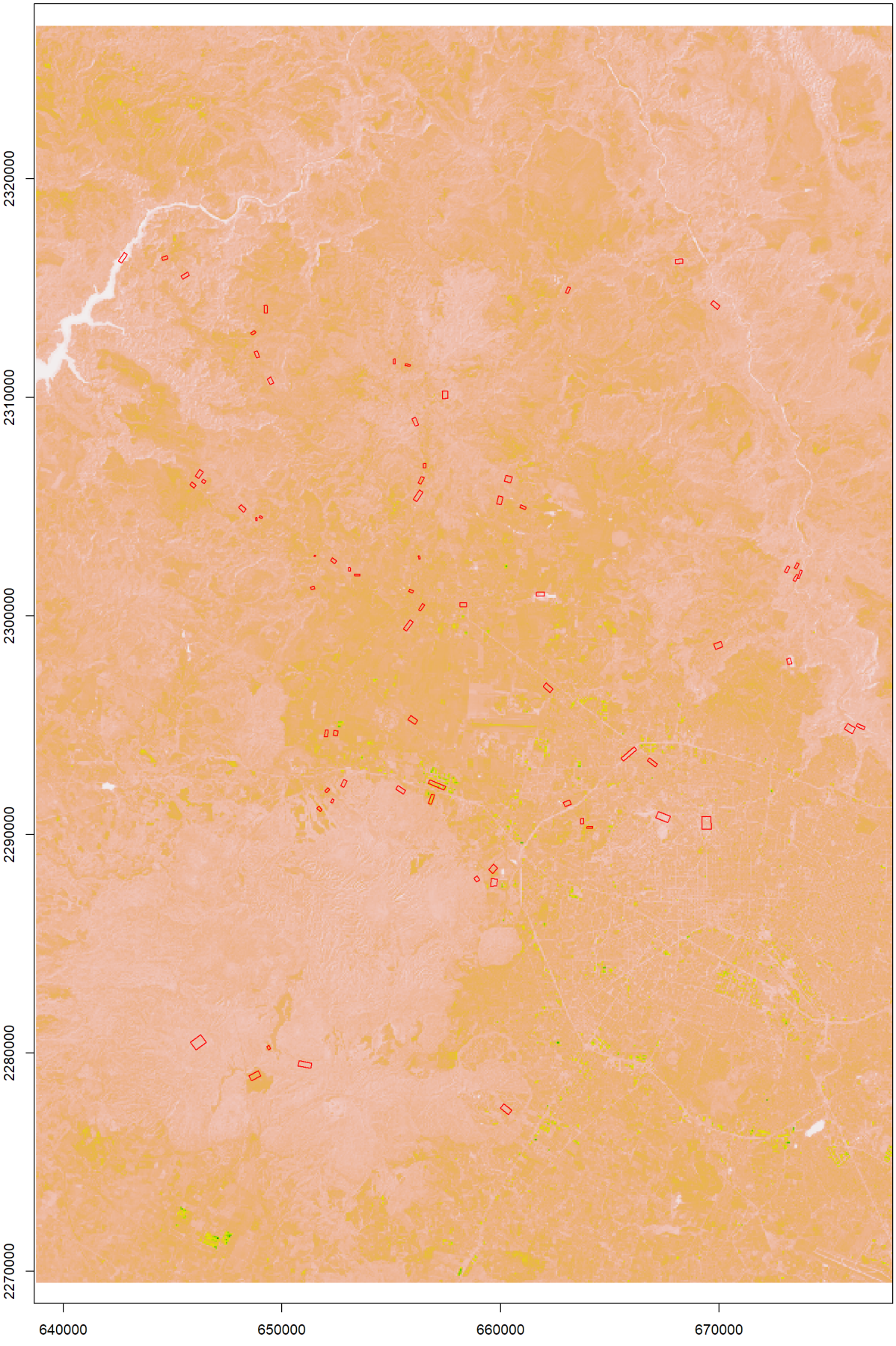
```
# load all layers of the source raster
raster_stack<-stack(raster_path)
dim(raster_stack)
```

```
## [1] 3840 2618    8
```

```
names(raster_stack) <- raster_layers_names
```

```
plot(raster_l1, axes = TRUE, legend = FALSE,
     main="Raster fuente y parcelas de control")
plot(control_parcels, border = "red", add = TRUE)
```

Raster fuente y parcelas de control



```
# reduce number of sampling zones to less then 100 for each class
for (j in 1:length(class_codes)) {
  main_class_subset <- main_class[main_class@data$CLASS == class_codes[j],]
  subzone_count <- 1 + floor(length(main_class_subset) / 100)
  if (verbose) {
    cat("Clase: ", class_codes[j], "\n")
    cat("      Número de zonas: ", length(main_class_subset), "\n")
    cat("      Número de subzonas inicial: ", subzone_count, "\n")
  }
  main_class_kfold_index <- kfold(main_class_subset, k = subzone_count)
  main_class_subset_kfold <- main_class_subset[main_class_kfold_index == 1,]
  if (verbose) {
    cat("      Numero de subzonas restante: ", length(main_class_subset_kfold), "\n")
  }
  if (j == 1) {
    main_class_kfold <- main_class_subset_kfold
  } else {
    main_class_kfold <- rbind(main_class_kfold, main_class_subset_kfold)
  }
}
cat("Numero de zonas de muestreo restante para todos clases: ",length(main_class_kfold),
"\n")
```

```
## Numero de zonas de muestreo restante para todos clases:  1224
```

```
# sampling
main_sampling <- extract(raster_stack, main_class_kfold)
```

```
# sampling
control_sampling <- extract(raster_stack, control_parcels)
```

Ejemplo de datos en class (promedio, sd, boxplot)

```
# review example unit of data
head(main_sampling[[1]])
```

```
##           pc1      pc2      pc3      pc4      pc5      pc6      pc7
## [1,] 45805.14 29610.96 18907.39 51923.57 19219.10 24441.85 23007.39
## [2,] 44700.15 31225.41 18423.84 51593.07 18567.01 24885.54 23339.13
## [3,] 44281.46 30665.68 18514.77 51473.67 17598.44 24758.86 23278.13
## [4,] 44636.04 31140.85 18424.63 51673.10 18458.59 24802.95 23297.02
## [5,] 47318.12 31790.99 19541.12 51235.63 20485.86 24921.20 23424.73
## [6,] 46158.75 30253.41 19820.68 50629.48 17738.49 24726.99 23344.65
##           pc8
## [1,] 25196.95
## [2,] 24911.82
## [3,] 25385.37
## [4,] 25256.88
## [5,] 24903.62
## [6,] 25604.50
```

```
main_class_kfold@data$CLASS[1]
```

```
## [1] 100
```

```
dim(main_sampling[[1]])[1]
```

```
## [1] 89
```

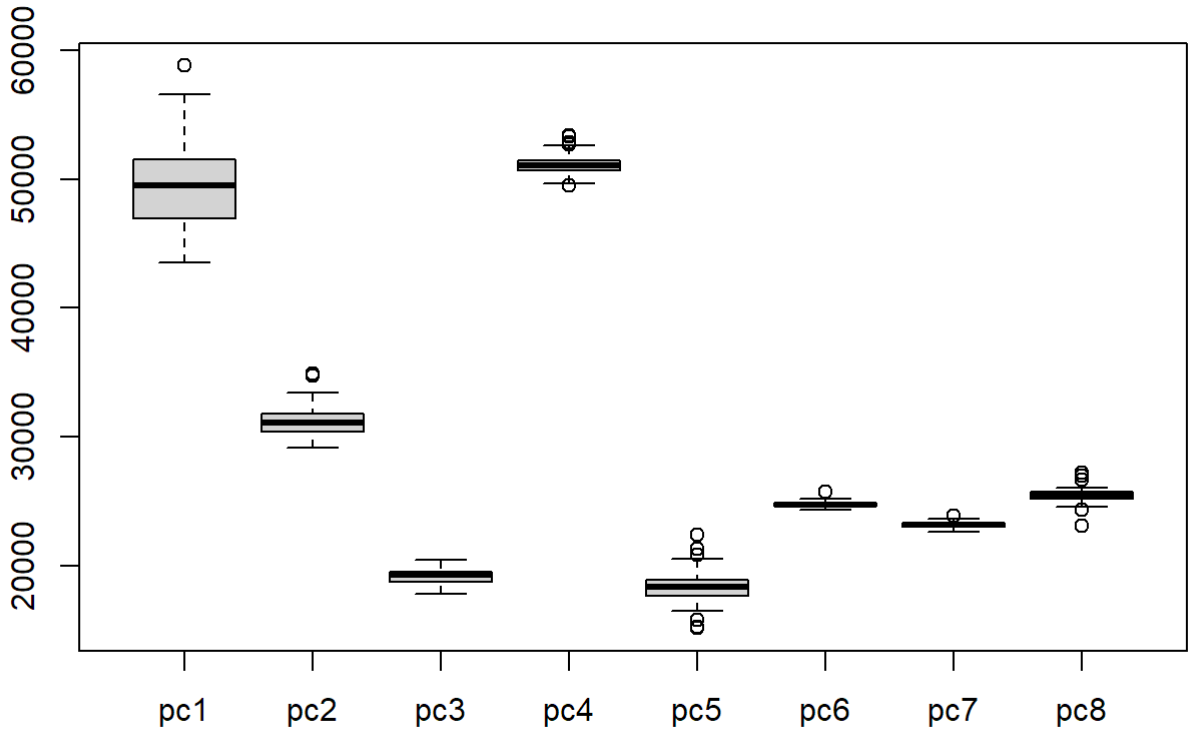
```
apply(main_sampling[[1]],2,mean)
```

```
##      pc1      pc2      pc3      pc4      pc5      pc6      pc7      pc8
## 49161.03 31150.13 19136.92 51155.57 18326.49 24749.79 23166.13 25434.48
```

```
apply(main_sampling[[1]],2,sd)
```

```
##       pc1       pc2       pc3       pc4       pc5       pc6       pc7
## 3036.6408 1098.1172  547.4662  739.2341 1185.9368  227.9075  258.0665
##       pc8
##  514.5812
```

```
boxplot(main_sampling[[1]], col = "lightgray")
```



Ejemplo de datos en parcela (promedio, sd, boxplot)

```
# review example unit of data
head(control_sampling[[1]])
```

```
##           pc1      pc2      pc3      pc4      pc5      pc6      pc7
## [1,] 46846.09 28860.39 19415.59 51007.31 17822.86 24288.69 22561.76
## [2,] 47768.64 29868.83 18943.46 51170.73 18726.11 24581.70 22561.53
## [3,] 47759.44 29846.29 18951.05 51171.02 18675.30 24590.62 22561.20
## [4,] 44951.42 29854.37 20262.03 51523.89 19139.68 24484.58 22914.38
## [5,] 44610.00 29397.61 20340.51 51393.83 18336.76 24402.23 22875.52
## [6,] 44446.09 27259.75 20071.73 50769.47 17499.38 24321.08 22780.80
##           pc8
## [1,] 25693.04
## [2,] 25126.93
## [3,] 25043.83
## [4,] 24997.36
## [5,] 25293.41
## [6,] 25345.50
```

```
control_parcels@data$Code_1[1]
```

```
## [1] 101
```

```
dim(control_sampling[[1]])[1]
```

```
## [1] 246
```

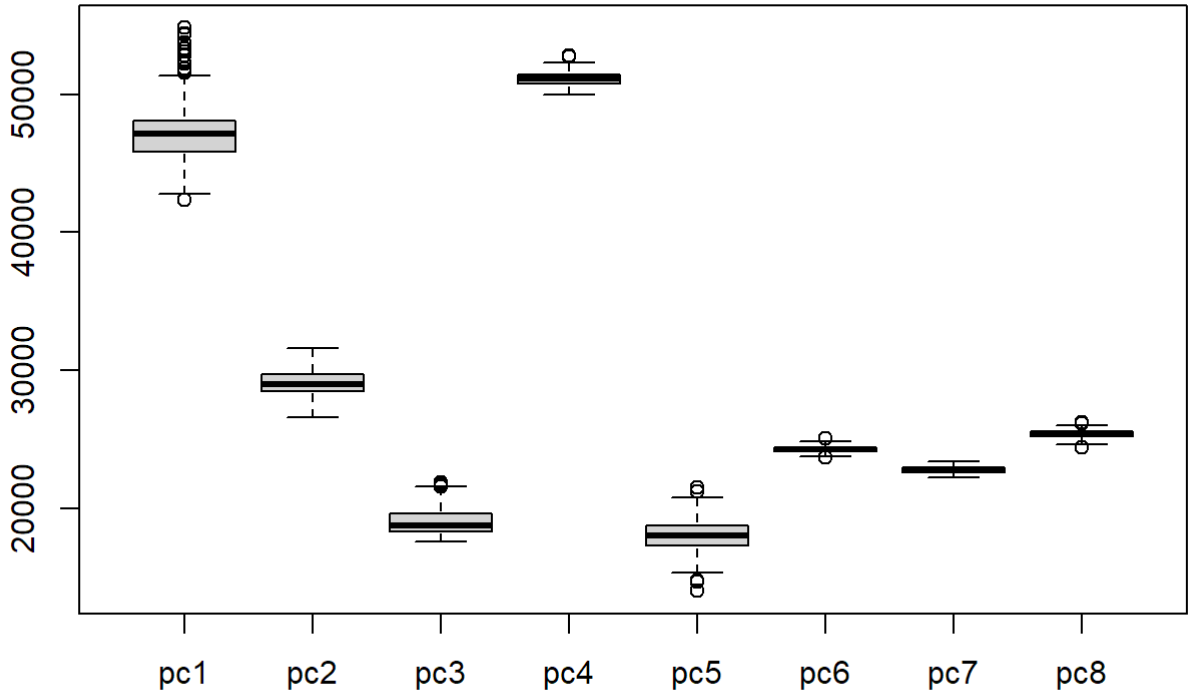
```
apply(control_sampling[[1]],2,mean)
```

```
##      pc1      pc2      pc3      pc4      pc5      pc6      pc7      pc8
## 47308.77 29085.91 19163.39 51119.87 18062.19 24326.99 22829.84 25388.83
```

```
apply(control_sampling[[1]],2,sd)
```

```
##       pc1       pc2       pc3       pc4       pc5       pc6       pc7
## 2307.7048  949.9949  999.3554  453.0548 1237.6978  226.4232  246.5324
##       pc8
##  289.4789
```

```
boxplot(control_sampling[[1]], col = "lightgray")
```



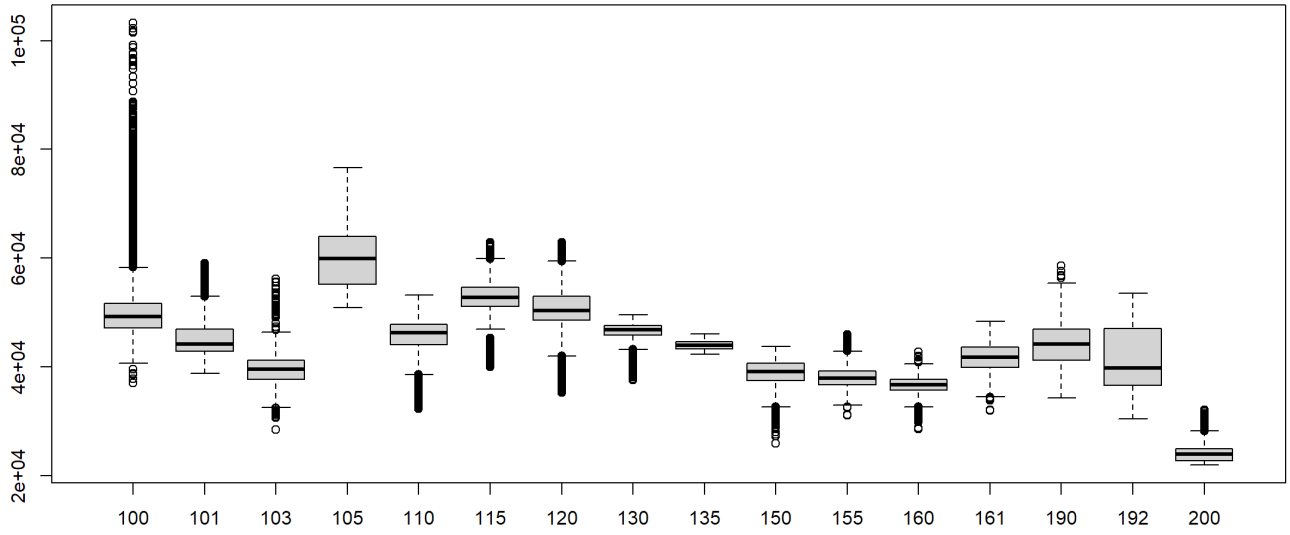
Tratamiento por clase

Reacomodo de datos por clases de muestreo principal

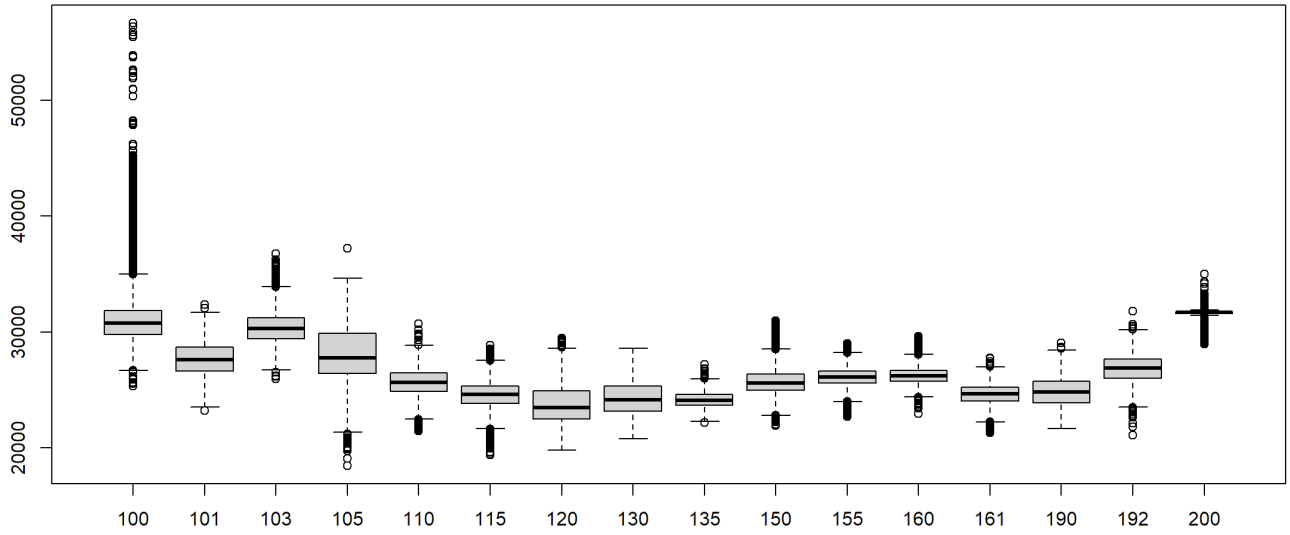
```
# rearrange data to data.frame
# create empty dataframe for main samping by class
main_sampling_df <- data.frame(matrix(ncol = raster_layers_count + 1, nrow = 0))
colnames(main_sampling_df) <- c(raster_layers_names,"CL")

# put sampling result into dataframe, the extra column is for class (CL)
for (i in 1:length(main_sampling)) {
  c_length <- dim(main_sampling[[i]])[1]
  id <- main_class_kfold@data$CLASS[i]
  fl <- cbind(main_sampling[[i]], CL = rep(id,c_length))
  main_sampling_df <- rbind(main_sampling_df,fl)
}

# optional standardize variables (only data columns)
#main_sampling_df[,c(1:raster_layers_count)] <- scale(main_sampling_df[,c(1:raster_layers_cou
nt)])
```

Resumen de datos por clase y calculo de promedios por clase

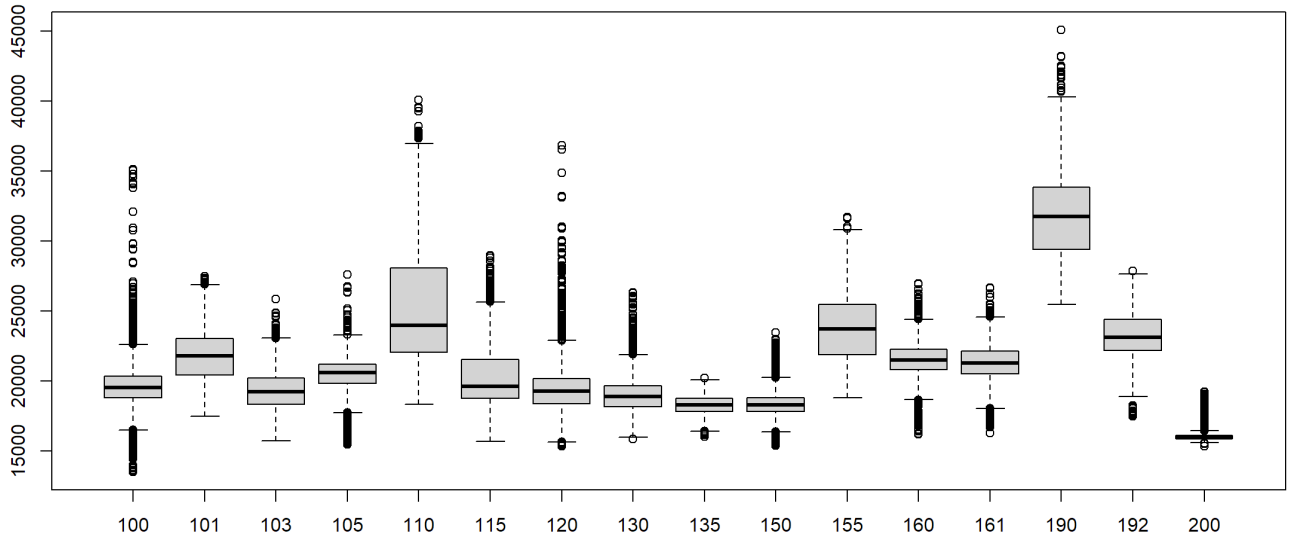
```
# visualize variables by class
boxplot( pc1 ~ CL, data = main_sampling_df, col = "lightgray")
```



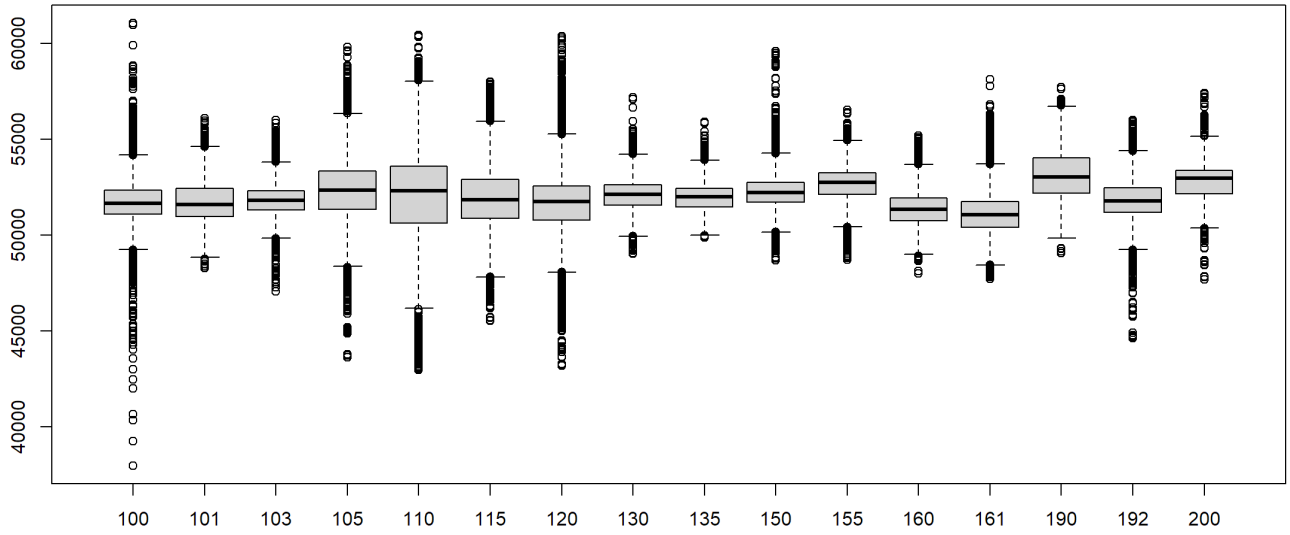

```
boxplot( pc2 ~ CL, data = main_sampling_df, col = "lightgray")
```



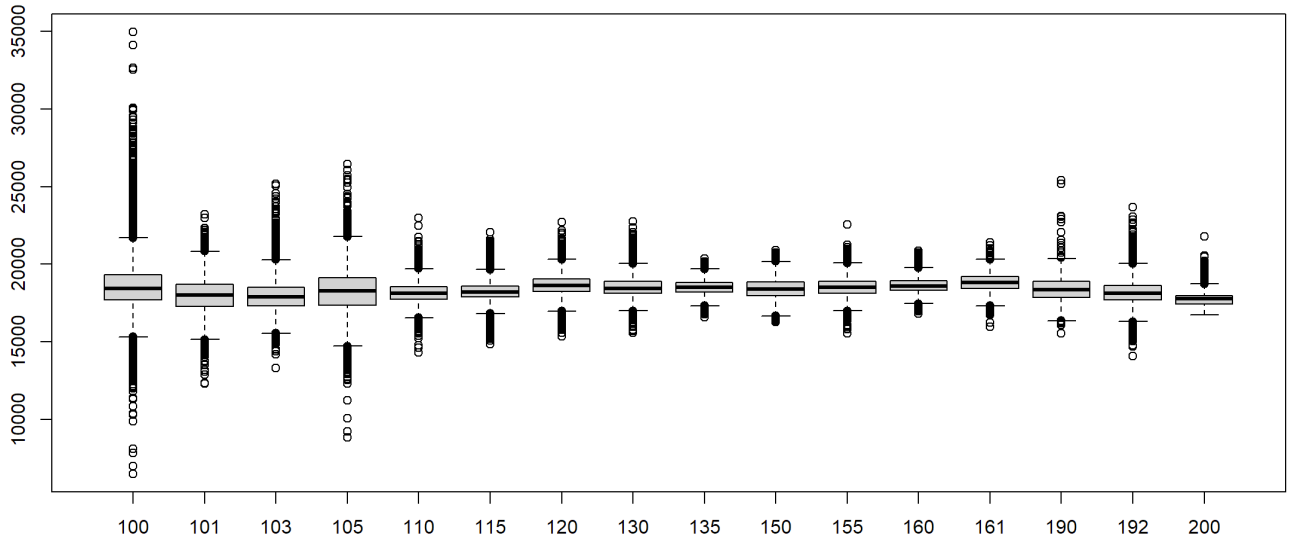

```
boxplot( pc3 ~ CL, data = main_sampling_df, col = "lightgray")
```



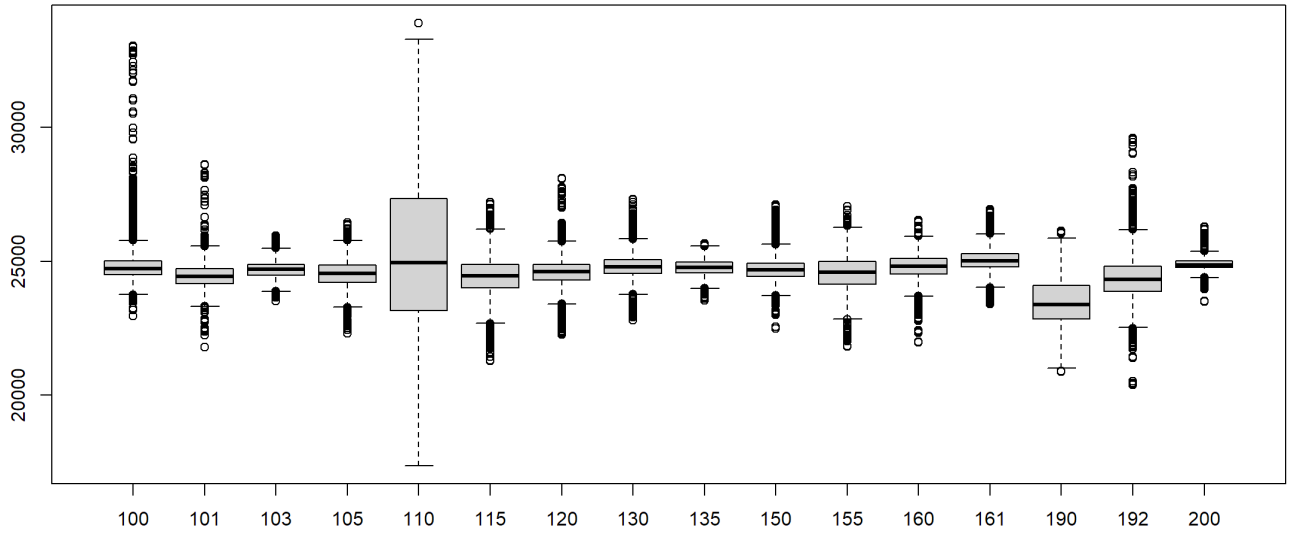

```
boxplot( pc4 ~ CL, data = main_sampling_df, col = "lightgray")
```



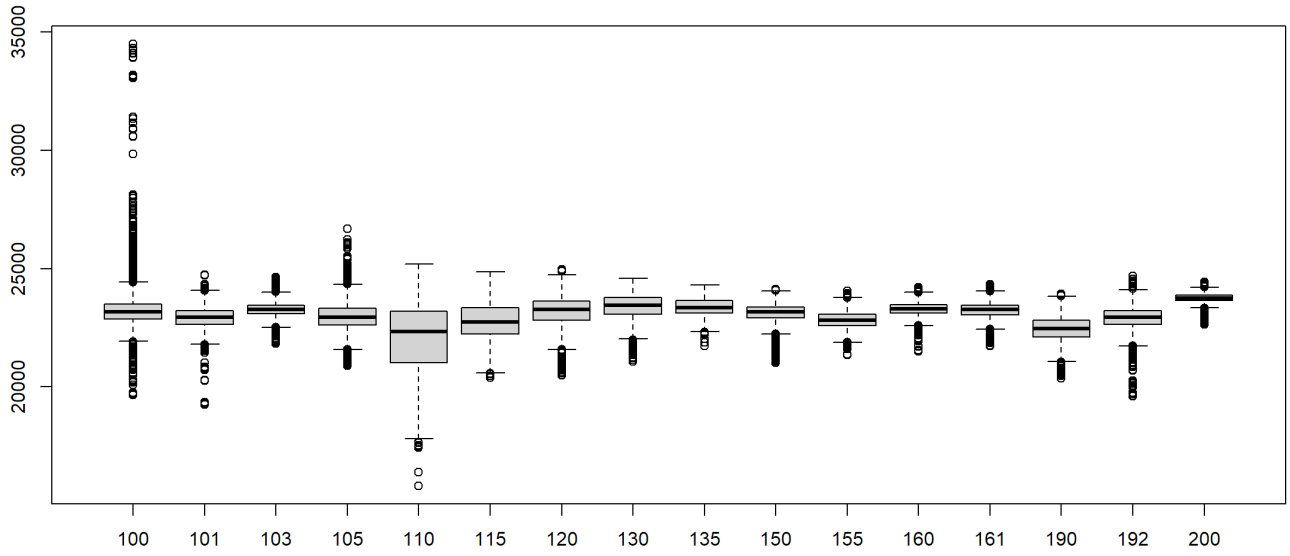

```
boxplot( pc5 ~ CL, data = main_sampling_df, col = "lightgray")
```



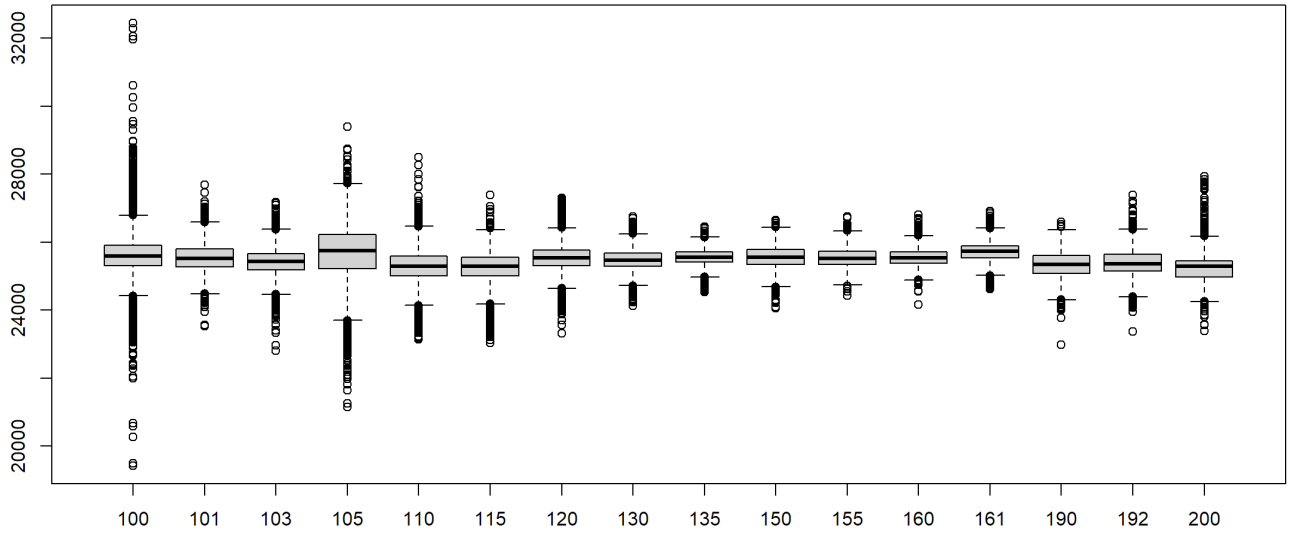

```
boxplot( pc6 ~ CL, data = main_sampling_df, col = "lightgray")
```




```
boxplot( pc7 ~ CL, data = main_sampling_df, col = "lightgray")
```




```
boxplot( pc8 ~ CL, data = main_sampling_df, col = "lightgray")
```




```
# calculate class means
M1 <-aggregate( . ~ CL, data = main_sampling_df, FUN = mean)
row.names(M1) <- M1$CL
raster_layers_count1 <- raster_layers_count + 1
M1 <- M1[,c(2:raster_layers_count1)]
M1
```

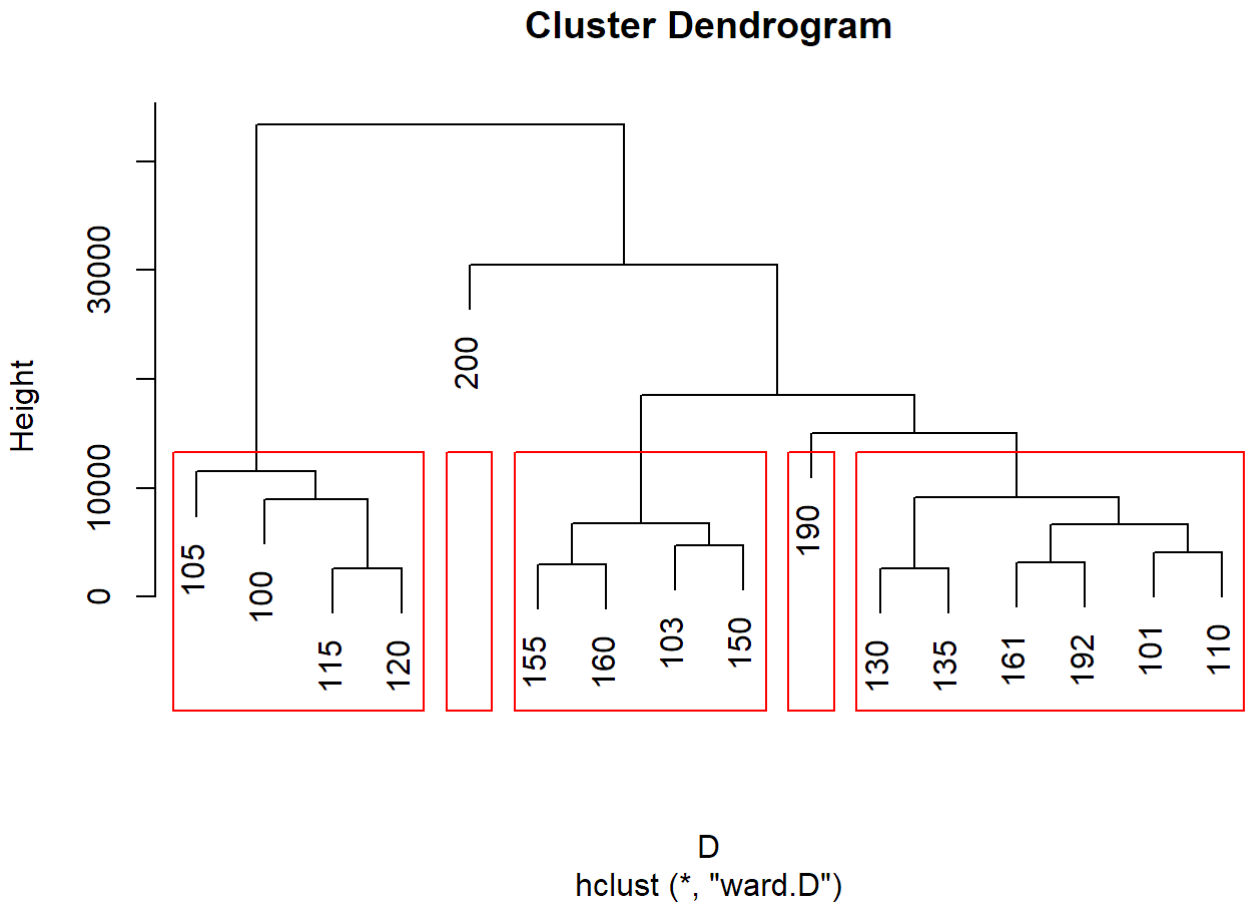
```
##          pc1      pc2      pc3      pc4      pc5      pc6      pc7
## 100 50955.04 31417.18 19686.99 51755.79 18673.07 24871.93 23273.72
## 101 45976.93 27681.62 21942.05 51768.15 18008.76 24462.50 22919.29
## 103 39405.37 30357.05 19361.31 51855.39 18000.92 24687.69 23270.62
## 105 60126.03 28040.96 20476.66 52330.88 18277.87 24538.77 22979.45
## 110 45569.22 25641.19 25318.06 52162.26 18166.06 25120.40 22086.78
## 115 52622.71 24556.73 20368.36 51859.68 18244.42 24445.27 22834.40
## 120 50414.76 23783.50 19377.48 51606.33 18648.65 24572.07 23175.60
## 130 46566.27 24274.30 19022.24 52110.84 18536.03 24815.91 23410.79
## 135 44032.84 24177.78 18297.46 51971.44 18509.03 24767.52 23382.10
## 150 38769.17 25813.25 18367.64 52260.74 18425.79 24680.99 23118.98
## 155 38108.93 26129.90 23701.52 52642.15 18542.93 24539.77 22819.87
## 160 36569.86 26283.04 21554.60 51343.15 18656.97 24772.93 23288.91
## 161 41836.76 24625.12 21328.81 51123.45 18814.24 25031.11 23237.72
## 190 44104.79 24801.93 31942.06 53127.35 18391.51 23462.38 22404.65
## 192 41557.33 26823.65 23237.02 51754.29 18197.15 24377.12 22867.19
## 200 24281.28 31606.47 16163.56 52879.62 17803.82 24855.37 23731.07
##          pc8
## 100 25639.30
## 101 25548.86
## 103 25415.60
## 105 25680.70
## 110 25302.16
## 115 25256.33
## 120 25535.20
## 130 25474.76
## 135 25561.17
## 150 25559.56
## 155 25543.02
## 160 25549.83
## 161 25711.46
## 190 25328.59
## 192 25399.21
## 200 25283.90
```

Relación entre clases

```
# Ward Hierarchical Clustering
D <- dist(M1, method = "euclidean")
fit <- hclust(D, method="ward")
```

```
## The "ward" method has been renamed to "ward.D"; note new "ward.D2"
```

```
plot(fit) # display dendogram
groups <- cutree(fit, k=5) # cut tree into 5 clusters
# draw dendogram with red borders around the 5 clusters
rect.hclust(fit, k=5, border="red")
```



Reacomodo de datos por zonas de muestreo principal

```
# rearrange data to data.frame
# create empty dataframe for main samping by zone
main_sampling_df2 <- data.frame(matrix(ncol = raster_layers_count + 1, nrow = 0))
colnames(main_sampling_df2) <- c(raster_layers_names,"ZN")

# put sampling result into dataframe, the extra column is for class (ZN)
for (i in 1:length(main_sampling)) {
  c_length <- dim(main_sampling[[i]])[1]
  id <- main_class_kfold@data$DISS_CODE[i]
  fl <- cbind(main_sampling[[i]], ZN = rep(id,c_length))
  main_sampling_df2 <- rbind(main_sampling_df2,fl)
  if (verbose) {
    print(id)
    print(main_class_kfold@data$CLASS[i])
   }
}
```

Calculo de promedios por zona

```
# calculate main sampling zone means
M3 <-aggregate( . ~ ZN, data = main_sampling_df2, FUN = mean)
row.names(M3) <- M3$ZN
raster_layers_count1 <- raster_layers_count + 1
M3 <- M3[,c(2:raster_layers_count1)]
#M3
```

Determinar clase mas probable para cada zona de “main sampling” (K-nearets neighbour)

```
# the order of elements in results of "aggregate" is not the same as in the original class,
# so it is necessary to sort the class labels in same order as training set
# following is to get original class label vector with same order as elements in M3
main_sampling_classes <- c()
M3_length <- dim(M3)[1]
for (i in 1:M3_length) {
  zone_code <- row.names(M3[i,])
  zone_subset <- main_class_kfold[main_class_kfold@data$DISS_CODE == zone_code,]
  zone_class <- zone_subset@data$CLASS
  if (verbose) {
    cat("Zona: ", zone_code,"\n")
    cat("Clase de zona: ", zone_class, "\n")
  }
  main_sampling_classes <- c(main_sampling_classes, zone_class)
}

# check the dataset dimensions
#dim(main_sampling_df2[,c(1:raster_layers_count)])
#dim(M3)
#length(main_sampling_df2[,"ZN"])

# Predict the most probable class for each parcel
prediction_M3 <- knn(main_sampling_df[,c(1:8)], # training set
                  M3,                          # test set
                  main_sampling_df[,"CL"],   # training class labels
                  k = 50, prob = TRUE)

M3_predict <- cbind(M3, prediction = prediction_M3, probability = attr(prediction_M3,
"prob"), original = main_sampling_classes)
table_M3_predict <- M3_predict[,c("original","prediction","probability")]
write.csv(table_M3_predict,file = "tabla_M3_predict.csv")
```

Tabla con valores de predicción para cada zona de “main sampling”

```
table_M3_predict
```

```
##          original prediction probability
## 12192         192        192   0.5200000
## 17103         103        103   1.0000000
## 19192         192        192   1.0000000
## 28110         110        101   0.6800000
## 33130         130        130   1.0000000
## 53101         101        101   0.4800000
## 59120         120        120   0.8600000
## 60160         160        160   1.0000000
## 63150         150        150   0.4400000
## 68135         135        135   1.0000000
## 75155         155        155   0.9400000
## 84161         161        161   1.0000000
## 91101         101        101   1.0000000
## 93161         161        161   1.0000000
## 96120         120        120   0.9000000
## 100130        130        130   0.7600000
## 119150        150        150   1.0000000
## 140135        135        135   1.0000000
## 145115        115        115   1.0000000
## 147155        155        161   0.5200000
## 150103        103        103   1.0000000
## 154192        192        110   0.5200000
## 158161        161        161   0.9800000
## 175161        161        161   0.9200000
## 177160        160        160   1.0000000
## 179150        150        150   1.0000000
## 191135        135        135   1.0000000
## 203135        135        135   1.0000000
## 205130        130        130   1.0000000
## 227103        103        103   1.0000000
## 233135        135        135   1.0000000
## 235150        150        150   0.9800000
## 243155        155        155   0.6400000
## 256103        103        103   1.0000000
## 268160        160        160   1.0000000
## 281101        101        101   0.9600000
## 283160        160        160   1.0000000
## 292150        150        150   1.0000000
## 323135        135        135   1.0000000
## 337103        103        103   1.0000000
## 340100        100        100   1.0000000
## 350160        160        160   0.9200000
## 361135        135        135   1.0000000
## 362105        105        105   1.0000000
## 363105        105        105   0.5800000
## 371161        161        161   1.0000000
## 376192        192        192   0.7000000
## 378103        103        103   1.0000000
## 392160        160        160   1.0000000
## 395192        192        192   0.4800000
## 400192        192        110   0.5000000
## 406130        130        130   1.0000000
## 421105        105        105   0.9400000
## 428155        155        161   0.7000000
## 476115        115        115   1.0000000
## 480135        135        135   1.0000000
```

```
## 483100        100        100   1.0000000
## 484120        120        120   0.6600000
## 504130        130        130   0.9400000
## 510101        101        101   0.9400000
## 515155        155        155   1.0000000
## 524200        200        200   1.0000000
## 528155        155        155   0.8600000
## 530120        120        115   0.9400000
## 537150        150        150   1.0000000
## 553103        103        103   1.0000000
## 566110        110        110   1.0000000
## 567100        100        100   1.0000000
## 588161        161        161   1.0000000
## 589105        105        120   0.6800000
## 592155        155        160   0.8000000
## 600130        130        130   1.0000000
## 601135        135        135   1.0000000
## 607115        115        115   0.9600000
## 608161        161        161   0.9600000
## 610115        115        115   1.0000000
## 627110        110        192   0.5000000
## 631130        130        130   1.0000000
## 641160        160        160   1.0000000
## 645120        120        120   1.0000000
## 647115        115        115   0.6000000
## 660130        130        130   1.0000000
## 669110        110        110   1.0000000
## 673110        110        110   0.8000000
## 676105        105        105   0.7800000
## 699105        105        105   1.0000000
## 703100        100        100   1.0000000
## 709100        100        100   1.0000000
## 722103        103        103   1.0000000
## 734190        190        190   0.8000000
## 736115        115        120   0.7800000
## 738160        160        150   0.8400000
## 743150        150        161   0.5200000
## 750150        150        161   0.5400000
## 758160        160        160   0.9200000
## 761160        160        160   0.7600000
## 764101        101        101   0.9400000
## 775120        120        115   0.7400000
## 777110        110        110   0.7400000
## 785120        120        120   1.0000000
## 786100        100        100   1.0000000
## 795160        160        160   0.9800000
## 810192        192        110   0.4800000
## 819100        100        100   1.0000000
## 824100        100        100   1.0000000
## 827161        161        161   0.8600000
## 833150        150        150   1.0000000
## 838161        161        161   0.9800000
## 850120        120        120   1.0000000
## 852155        155        155   0.9000000
## 856110        110        110   0.5000000
## 857105        105        105   0.9600000
## 858130        130        161   0.6800000
## 862161        161        161   1.0000000
```

```
## 875103       103        103   1.0000000
## 882105       105        105   0.9200000
## 889160       160        160   0.9600000
## 914200       200        200   1.0000000
## 918103       103        103   1.0000000
## 920101       101        101   0.9800000
## 922150       150        150   1.0000000
## 923120       120        120   1.0000000
## 927103       103        150   0.6200000
## 930115       115        110   0.6400000
## 931150       150        150   1.0000000
## 936120       120        120   1.0000000
## 938130       130        130   0.9400000
## 954100       100        100   1.0000000
## 1007161      161        161   1.0000000
## 1009110      110        110   0.5400000
## 1020150      150        150   0.9800000
## 1022101      101        192   0.7000000
## 1023150      150        150   1.0000000
## 1037161      161        161   1.0000000
## 1046105      105        105   1.0000000
## 1053135      135        135   1.0000000
## 1061105      105        105   1.0000000
## 1066130      130        130   1.0000000
## 1069103      103        103   1.0000000
## 1081101      101        100   1.0000000
## 1088120      120        120   0.9600000
## 1107130      130        130   1.0000000
## 1119120      120        120   0.6800000
## 1138110      110        101   0.6800000
## 1145103      103        103   1.0000000
## 1149135      135        135   1.0000000
## 1175130      130        130   0.9400000
## 1191155      155        155   0.9200000
## 1192135      135        135   1.0000000
## 1204120      120        120   1.0000000
## 1208160      160        160   0.9200000
## 1214120      120        120   0.7000000
## 1219115      115        115   1.0000000
## 1229161      161        161   1.0000000
## 1244155      155        155   1.0000000
## 1255101      101        155   0.4600000
## 1269100      100        100   0.9800000
## 1276103      103        103   1.0000000
## 1281100      100        100   1.0000000
## 1283155      155        160   0.4600000
## 1288120      120        120   1.0000000
## 1294135      135        135   1.0000000
## 1301100      100        100   1.0000000
## 1302130      130        130   1.0000000
## 1304115      115        115   1.0000000
## 1305190      190        190   0.8000000
## 1313192      192        101   0.9000000
## 1330192      192        192   0.6400000
## 1335190      190        190   0.6400000
## 1348130      130        130   0.8600000
## 1361130      130        130   0.5000000
## 1368135      135        135   1.0000000
```

```
## 1373130       130        130   1.0000000
## 1382155       155        155   0.9200000
## 1384150       150        150   1.0000000
## 1387101       101        101   0.8800000
## 1388161       161        161   1.0000000
## 1389161       161        161   1.0000000
## 1391200       200        200   1.0000000
## 1393105       105        105   1.0000000
## 1394120       120        120   0.8200000
## 1401135       135        135   1.0000000
## 1411135       135        135   1.0000000
## 1416190       190        190   0.6400000
## 1424101       101        101   0.6400000
## 1433115       115        115   0.8600000
## 1463161       161        161   1.0000000
## 1486130       130        130   0.9800000
## 1493192       192        101   0.5000000
## 1495155       155        155   0.8800000
## 1497130       130        130   0.9800000
## 1514110       110        110   1.0000000
## 1519101       101        101   0.9200000
## 1529101       101        101   0.8200000
## 1536120       120        120   1.0000000
## 1538120       120        120   1.0000000
## 1541110       110        110   0.8200000
## 1562105       105        105   1.0000000
## 1581130       130        130   1.0000000
## 1583161       161        161   1.0000000
## 1587160       160        160   0.9000000
## 1589101       101        101   0.8400000
## 1606120       120        120   1.0000000
## 1608160       160        160   1.0000000
## 1611155       155        161   0.5200000
## 1616120       120        120   1.0000000
## 1635135       135        135   1.0000000
## 1640100       100        100   1.0000000
## 1644190       190        190   0.9800000
## 1645160       160        160   0.9200000
## 1648150       150        150   1.0000000
## 1649192       192        160   0.5600000
## 1653100       100        100   1.0000000
## 1659100       100        100   1.0000000
## 1663150       150        150   0.6400000
## 1695120       120        120   1.0000000
## 1697115       115        115   0.8400000
## 1700200       200        200   1.0000000
## 1702120       120        120   0.9600000
## 1708120       120        115   0.5400000
## 1718100       100        100   1.0000000
## 1723101       101        101   1.0000000
## 1730130       130        130   0.7000000
## 1731130       130        130   1.0000000
## 1733135       135        135   1.0000000
## 1735150       150        150   0.8800000
## 1736115       115        120   0.6000000
## 1737110       110        192   0.6000000
## 1757100       100        100   1.0000000
## 1759130       130        130   1.0000000
```

```
## 1770150       150        150   1.0000000
## 1773135       135        135   1.0000000
## 1788103       103        103   1.0000000
## 1810135       135        135   1.0000000
## 1812161       161        161   1.0000000
## 1816135       135        135   1.0000000
## 1823200       200        200   1.0000000
## 1836115       115        115   0.9200000
## 1841103       103        103   1.0000000
## 1846135       135        135   1.0000000
## 1855115       115        115   1.0000000
## 1865115       115        115   0.8600000
## 1877150       150        150   0.8600000
## 1878105       105        105   1.0000000
## 1897160       160        160   1.0000000
## 1898103       103        103   1.0000000
## 1899100       100        100   1.0000000
## 1901115       115        115   1.0000000
## 1920101       101        101   0.9400000
## 1924150       150        150   1.0000000
## 1942160       160        160   1.0000000
## 1947100       100        100   0.6600000
## 1949103       103        103   1.0000000
## 1950101       101        101   0.8600000
## 1952192       192        110   0.7200000
## 1954105       105        105   1.0000000
## 1985100       100        100   1.0000000
## 2011103       103        103   1.0000000
## 2012130       130        130   1.0000000
## 2013160       160        160   0.9600000
## 2019120       120        120   0.9800000
## 2022120       120        120   0.9600000
## 2032130       130        130   1.0000000
## 2043101       101        101   0.9600000
## 2046161       161        161   1.0000000
## 2056135       135        135   1.0000000
## 2057161       161        161   1.0000000
## 2059192       192        160   0.7000000
## 2061110       110        110   1.0000000
## 2067115       115        115   0.5000000
## 2068135       135        135   1.0000000
## 2076161       161        161   1.0000000
## 2079155       155        155   0.7400000
## 2081120       120        120   0.9200000
## 2094101       101        101   0.8400000
## 2108155       155        160   0.5400000
## 2112120       120        120   1.0000000
## 2127110       110        110   1.0000000
## 2135150       150        150   1.0000000
## 2146103       103        103   1.0000000
## 2166101       101        101   0.9200000
## 2167135       135        135   1.0000000
## 2170101       101        101   0.9800000
## 2172200       200        200   1.0000000
## 2177110       110        110   0.9000000
## 2196135       135        135   1.0000000
## 2197155       155        155   0.8800000
## 2202101       101        101   0.8600000
```

```
## 2206100       100        100   1.0000000
## 2207115       115        115   0.6800000
## 2209160       160        160   0.8400000
## 2210100       100        100   1.0000000
## 2211161       161        161   1.0000000
## 2213161       161        161   1.0000000
## 2232161       161        161   1.0000000
## 2245120       120        120   0.9200000
## 2247101       101        101   0.9800000
## 2254120       120        120   0.9600000
## 2256161       161        161   1.0000000
## 2259103       103        103   1.0000000
## 2260101       101        101   0.9019608
## 2262110       110        110   1.0000000
## 2275192       192        192   0.8800000
## 2281190       190        190   0.7200000
## 2301150       150        150   1.0000000
## 2311100       100        100   1.0000000
## 2320103       103        103   1.0000000
## 2339120       120        120   1.0000000
## 2358200       200        200   1.0000000
## 2361150       150        150   1.0000000
## 2369110       110        110   0.7800000
## 2371101       101        101   0.9800000
## 2386160       160        160   0.8000000
## 2387110       110        110   1.0000000
## 2388103       103        103   1.0000000
## 2417103       103        103   1.0000000
## 2434150       150        150   0.6800000
## 2441105       105        101   0.5200000
## 2446192       192        192   0.7200000
## 2454155       155        160   0.5800000
## 2457200       200        200   1.0000000
## 2465155       155        155   0.5200000
## 2475101       101        101   0.6000000
## 2478110       110        110   1.0000000
## 2482150       150        150   1.0000000
## 2510190       190        110   0.6800000
## 2531100       100        100   1.0000000
## 2533100       100        100   1.0000000
## 2535130       130        130   0.9600000
## 2553110       110        110   0.9600000
## 2561150       150        150   1.0000000
## 2572115       115        115   1.0000000
## 2579155       155        155   0.9400000
## 2581115       115        115   0.6800000
## 2582160       160        160   1.0000000
## 2599161       161        161   1.0000000
## 2601135       135        135   1.0000000
## 2602101       101        100   1.0000000
## 2617103       103        103   0.8000000
## 2618105       105        105   1.0000000
## 2624160       160        160   0.8600000
## 2640103       103        103   1.0000000
## 2652115       115        115   0.9200000
## 2658120       120        120   0.9800000
## 2666161       161        161   1.0000000
## 2672160       160        160   1.0000000
```

```
## 2675120       120        120   0.7000000
## 2676135       135        135   1.0000000
## 2677160       160        160   0.9600000
## 2679192       192        192   0.4600000
## 2690192       192        192   0.5800000
## 2714110       110        110   0.7600000
## 2727190       190        190   0.8200000
## 2747200       200        200   1.0000000
## 2753110       110        110   0.8400000
## 2769130       130        130   1.0000000
## 2770160       160        160   0.9800000
## 2777100       100        100   1.0000000
## 2789115       115        115   1.0000000
## 2791161       161        161   0.9800000
## 2792160       160        192   0.6078431
## 2794120       120        120   1.0000000
## 2796110       110        110   0.8000000
## 2798110       110        110   0.7800000
## 2806110       110        110   0.8000000
## 2826115       115        115   1.0000000
## 2849190       190        190   0.8000000
## 2859103       103        103   1.0000000
## 2868105       105        105   0.4800000
## 2875115       115        115   0.6200000
## 2892135       135        135   1.0000000
## 2901120       120        115   0.6400000
## 2921161       161        161   1.0000000
## 2936150       150        150   1.0000000
## 2939150       150        150   1.0000000
## 2947130       130        130   1.0000000
## 2950160       160        160   0.9600000
## 2959100       100        100   1.0000000
## 2966150       150        150   1.0000000
## 2982120       120        110   0.5882353
## 2985120       120        120   1.0000000
## 2989160       160        160   1.0000000
## 2993150       150        150   1.0000000
## 2997120       120        120   0.8400000
## 3025200       200        200   1.0000000
## 3026150       150        150   1.0000000
## 3036192       192        110   0.5600000
## 3038115       115        115   0.6400000
## 3040110       110        110   0.7200000
## 3045105       105        105   1.0000000
## 3050161       161        161   1.0000000
## 3051120       120        120   1.0000000
## 3064101       101        101   0.7400000
## 3065120       120        120   1.0000000
## 3089192       192        160   0.6800000
## 3151105       105        105   1.0000000
## 3161115       115        115   0.6800000
## 3169161       161        161   0.8000000
## 3205160       160        160   0.8000000
## 3215105       105        115   0.6200000
## 3216130       130        155   0.4200000
## 3222130       130        130   1.0000000
## 3230160       160        160   1.0000000
## 3241103       103        103   1.0000000
```

```
## 3244155       155         155   0.7000000
## 3261115       115         115   0.9400000
## 3262130       130         130   1.0000000
## 3263200       200         200   1.0000000
## 3266200       200         200   1.0000000
## 3281161       161         161   1.0000000
## 3283150       150         150   0.9200000
## 3284120       120         130   1.0000000
## 3296115       115         115   0.9800000
## 3310115       115         115   0.7000000
## 3311161       161         161   0.8600000
## 3312161       161         161   1.0000000
## 3345190       190         190   0.6000000
## 3346110       110         110   0.7400000
## 3352105       105         105   1.0000000
## 3359100       100         100   1.0000000
## 3360101       101         101   0.6000000
## 3364192       192         192   0.8600000
## 3367161       161         161   1.0000000
## 3372103       103         103   1.0000000
## 3399100       100         100   1.0000000
## 3403120       120         120   1.0000000
## 3414135       135         135   1.0000000
## 3419161       161         161   1.0000000
## 3431192       192         110   0.5200000
## 3438200       200         200   1.0000000
## 3439190       190         190   0.8600000
## 3449105       105         105   1.0000000
## 3453155       155         160   0.8400000
## 3465150       150         150   1.0000000
## 3475110       110         110   1.0000000
## 3478161       161         161   0.9600000
## 3502190       190         190   0.6400000
## 3504100       100         100   1.0000000
## 3510160       160         160   0.9800000
## 3518192       192         110   0.7400000
## 3525100       100         100   1.0000000
## 3532135       135         135   1.0000000
## 3560120       120         120   1.0000000
## 3564105       105         105   0.9600000
## 3575192       192         120   0.3000000
## 3578190       190         190   0.6000000
## 3580135       135         135   1.0000000
## 3589160       160         160   1.0000000
## 3592101       101         101   0.4400000
## 3602161       161         161   0.8200000
## 3640101       101         101   0.7200000
## 3649100       100         100   1.0000000
## 3653105       105         105   0.8800000
## 3698192       192         155   0.6000000
## 3720161       161         161   1.0000000
## 3723150       150         150   1.0000000
## 3730120       120         120   1.0000000
## 3732115       115         115   1.0000000
## 3742115       115         115   1.0000000
## 3771103       103         103   1.0000000
## 3777160       160         160   0.8400000
## 3794200       200         200   1.0000000
```

```
## 3814200       200         200   1.0000000
## 3818135       135         135   1.0000000
## 3821115       115         115   0.5400000
## 3826161       161         161   1.0000000
## 3829120       120         120   0.9600000
## 3830150       150         150   1.0000000
## 3831100       100         100   1.0000000
## 3854161       161         161   0.8200000
## 3874103       103         103   1.0000000
## 3883155       155         155   0.8000000
## 3897130       130         130   1.0000000
## 3903130       130         130   1.0000000
## 3907161       161         161   1.0000000
## 3921161       161         161   0.9800000
## 3923115       115         115   1.0000000
## 3928155       155         155   0.7400000
## 3935101       101         101   0.7200000
## 3951150       150         150   1.0000000
## 3952155       155         155   0.5800000
## 3957135       135         135   1.0000000
## 3977200       200         200   1.0000000
## 4003130       130         130   1.0000000
## 4029192       192         192   0.7200000
## 4031192       192         192   1.0000000
## 4033100       100         100   1.0000000
## 4048103       103         103   1.0000000
## 4055100       100         100   1.0000000
## 4060103       103         103   1.0000000
## 4063135       135         135   1.0000000
## 4067103       103         103   1.0000000
## 4071103       103         103   1.0000000
## 4075120       120         120   0.6400000
## 4076110       110         110   1.0000000
## 4095161       161         161   1.0000000
## 4111135       135         135   1.0000000
## 4130105       105         105   1.0000000
## 4135135       135         135   1.0000000
## 4139130       130         130   0.9800000
## 4142161       161         161   0.7600000
## 4146110       110         110   1.0000000
## 4153155       155         155   0.5000000
## 4175105       105         105   1.0000000
## 4179120       120         120   1.0000000
## 4181150       150         150   0.9400000
## 4183161       161         161   0.9000000
## 4191160       160         160   0.9400000
## 4214155       155         155   0.5000000
## 4217100       100         100   0.9800000
## 4237100       100         100   1.0000000
## 4239130       130         130   1.0000000
## 4242105       105         105   1.0000000
## 4260150       150         150   0.9800000
## 4261192       192         192   0.8800000
## 4273100       100         100   1.0000000
## 4274100       100         100   0.9800000
## 4285150       150         150   1.0000000
## 4290120       120         120   0.9600000
## 4294161       161         161   0.9000000
```

```
## 4295155       155        155   0.7600000
## 4296101       101        101   0.6800000
## 4315155       155        155   0.8800000
## 4317103       103        103   1.0000000
## 4319115       115        115   0.9200000
## 4331105       105        105   1.0000000
## 4335150       150        150   0.9400000
## 4341120       120        120   1.0000000
## 4377100       100        100   0.7400000
## 4379155       155        155   0.8000000
## 4397130       130        130   1.0000000
## 4399160       160        160   1.0000000
## 4405120       120        120   1.0000000
## 4419105       105        105   1.0000000
## 4421200       200        200   1.0000000
## 4437120       120        120   1.0000000
## 4439160       160        160   0.5600000
## 4444100       100        100   1.0000000
## 4445103       103        103   1.0000000
## 4449135       135        135   1.0000000
## 4451103       103        103   1.0000000
## 4460120       120        120   0.9200000
## 4463100       100        100   1.0000000
## 4477103       103        103   1.0000000
## 4481115       115        115   0.9800000
## 4482110       110        110   0.6800000
## 4485130       130        130   1.0000000
## 4489103       103        103   1.0000000
## 4504130       130        130   1.0000000
## 4518130       130        130   1.0000000
## 4530150       150        150   1.0000000
## 4545130       130        130   1.0000000
## 4562110       110        190   0.4200000
## 4567192       192        101   0.7000000
## 4568100       100        100   1.0000000
## 4580150       150        150   1.0000000
## 4584100       100        100   1.0000000
## 4613160       160        160   1.0000000
## 4623115       115        115   1.0000000
## 4628115       115        115   1.0000000
## 4633103       103        103   1.0000000
## 4639150       150        150   1.0000000
## 4641150       150        150   1.0000000
## 4682135       135        135   1.0000000
## 4690161       161        161   1.0000000
## 4691161       161        161   1.0000000
## 4697100       100        100   1.0000000
## 4702100       100        100   1.0000000
## 4717115       115        115   1.0000000
## 4719161       161        161   1.0000000
## 4726110       110        110   0.7600000
## 4750155       155        155   0.4600000
## 4782101       101        101   0.6400000
## 4784200       200        200   1.0000000
## 4790130       130        130   1.0000000
## 4794130       130        130   0.9400000
## 4804150       150        150   1.0000000
## 4811115       115        115   1.0000000
```

```
## 4813105       105        105   1.0000000
## 4816150       150        150   1.0000000
## 4828115       115        115   0.9400000
## 4832161       161        161   1.0000000
## 4843115       115        115   0.8600000
## 4844115       115        115   1.0000000
## 4846100       100        100   1.0000000
## 4847190       190        190   0.8400000
## 4864130       130        130   1.0000000
## 4870101       101        101   0.7400000
## 4875161       161        161   1.0000000
## 4882160       160        160   0.8800000
## 4890105       105        105   0.9000000
## 4896101       101        101   0.7000000
## 4918100       100        100   1.0000000
## 4920150       150        161   0.9200000
## 4922135       135        135   1.0000000
## 4925130       130        130   1.0000000
## 4931155       155        155   0.9200000
## 4949115       115        115   0.7800000
## 4959190       190        190   0.9400000
## 4961100       100        100   0.9200000
## 4962135       135        135   1.0000000
## 4964161       161        161   0.8000000
## 4967105       105        105   1.0000000
## 4969115       115        115   1.0000000
## 4972101       101        101   0.8800000
## 4997115       115        115   0.8400000
## 5001161       161        161   1.0000000
## 5004103       103        103   1.0000000
## 5006150       150        150   0.9800000
## 5013161       161        161   1.0000000
## 5016130       130        130   1.0000000
## 5025200       200        200   1.0000000
## 5026155       155        155   0.5400000
## 5040115       115        115   1.0000000
## 5044200       200        200   1.0000000
## 5053105       105        105   1.0000000
## 5064200       200        200   1.0000000
## 5069105       105        105   1.0000000
## 5074150       150        150   1.0000000
## 5079120       120        120   0.8800000
## 5098155       155        155   0.8400000
## 5099155       155        155   0.7400000
## 5105115       115        105   0.7600000
## 5109160       160        160   0.9200000
## 5122115       115        115   1.0000000
## 5133130       130        130   1.0000000
## 5138105       105        105   0.7200000
## 5143135       135        135   1.0000000
## 5146160       160        160   0.9200000
## 5150192       192        192   0.7000000
## 5152120       120        120   0.9800000
## 5154130       130        130   0.9200000
## 5156130       130        130   0.9400000
## 5158110       110        110   0.7800000
## 5159105       105        105   1.0000000
## 5177200       200        200   1.0000000
```

```
## 5181103       103        103   1.0000000
## 5183103       103        103   1.0000000
## 5188130       130        130   0.9400000
## 5192130       130        130   1.0000000
## 5217105       105        101   0.7600000
## 5218135       135        135   1.0000000
## 5219150       150        150   0.9607843
## 5221101       101        101   0.9800000
## 5241120       120        110   0.5800000
## 5244115       115        115   0.8800000
## 5253130       130        130   1.0000000
## 5257150       150        150   1.0000000
## 5275160       160        160   1.0000000
## 5289105       105        105   1.0000000
## 5293160       160        150   0.8600000
## 5294120       120        120   1.0000000
## 5299101       101        101   0.9800000
## 5311115       115        115   0.9200000
## 5318115       115        115   1.0000000
## 5358130       130        130   1.0000000
## 5365101       101        100   0.6800000
## 5370115       115        115   1.0000000
## 5371160       160        160   1.0000000
## 5374160       160        160   1.0000000
## 5378115       115        115   1.0000000
## 5384103       103        103   1.0000000
## 5396110       110        190   0.5800000
## 5399101       101        101   0.9600000
## 5401100       100        100   1.0000000
## 5422130       130        130   0.9200000
## 5456101       101        101   0.6000000
## 5463160       160        160   1.0000000
## 5473115       115        115   1.0000000
## 5500115       115        120   0.5600000
## 5511190       190        190   0.7800000
## 5517100       100        100   1.0000000
## 5531100       100        100   0.5800000
## 5551192       192        192   0.8200000
## 5554192       192        192   0.7200000
## 5556105       105        105   1.0000000
## 5571160       160        160   1.0000000
## 5587110       110        110   0.7800000
## 5590110       110        110   0.7600000
## 5629103       103        103   1.0000000
## 5633150       150        150   1.0000000
## 5640100       100        100   1.0000000
## 5644120       120        120   0.8600000
## 5651120       120        120   0.5800000
## 5671192       192        192   0.6200000
## 5680192       192        101   0.4800000
## 5683101       101        101   0.9400000
## 5692200       200        200   1.0000000
## 5693135       135        135   1.0000000
## 5703161       161        161   1.0000000
## 5726150       150        150   1.0000000
## 5747135       135        135   1.0000000
## 5753161       161        161   0.9800000
## 5756120       120        120   0.7800000
```

```
## 5760192       192         103   0.6600000
## 5766130       130         130   1.0000000
## 5770115       115         115   1.0000000
## 5776120       120         120   0.8200000
## 5794150       150         150   1.0000000
## 5796150       150         150   1.0000000
## 5797135       135         135   1.0000000
## 5812160       160         160   1.0000000
## 5816155       155         160   0.5800000
## 5829135       135         135   1.0000000
## 5832110       110         110   1.0000000
## 5837110       110         190   0.5800000
## 5846103       103         103   1.0000000
## 5848200       200         200   1.0000000
## 5849103       103         103   1.0000000
## 5858135       135         135   1.0000000
## 5876100       100         100   1.0000000
## 5879160       160         160   1.0000000
## 5889103       103         103   1.0000000
## 5899115       115         115   0.7000000
## 5909160       160         160   0.9800000
## 5911101       101         101   1.0000000
## 5923200       200         200   1.0000000
## 5925192       192         101   0.8600000
## 5932130       130         130   1.0000000
## 5937115       115         115   0.8000000
## 5938135       135         135   1.0000000
## 5947130       130         130   1.0000000
## 5949120       120         120   1.0000000
## 5952160       160         160   1.0000000
## 5954155       155         155   0.9600000
## 5964100       100         100   1.0000000
## 5998130       130         130   1.0000000
## 6008115       115         115   0.6000000
## 6012110       110         130   0.5800000
## 6014120       120         120   1.0000000
## 6020115       115         115   0.9600000
## 6023100       100         100   1.0000000
## 6031105       105         105   1.0000000
## 6042103       103         103   1.0000000
## 6043150       150         150   1.0000000
## 6045100       100         100   1.0000000
## 6046135       135         135   1.0000000
## 6049110       110         110   0.7000000
## 6057155       155         155   0.9800000
## 6062115       115         101   0.6666667
## 6069150       150         150   1.0000000
## 6077105       105         105   1.0000000
## 6090161       161         161   0.9200000
## 6091160       160         160   0.9200000
## 6092101       101         101   0.8800000
## 6098103       103         103   1.0000000
## 6105130       130         130   0.5200000
## 6120115       115         115   0.9800000
## 6129150       150         150   1.0000000
## 6131115       115         115   0.8400000
## 6134120       120         120   0.9200000
## 6139150       150         150   1.0000000
```

```
## 6147120       120        120   0.9200000
## 6155155       155        155   0.5200000
## 6162100       100        100   1.0000000
## 6169161       161        161   1.0000000
## 6172103       103        103   1.0000000
## 6186100       100        100   1.0000000
## 6190120       120        120   0.9200000
## 6194150       150        150   1.0000000
## 6210192       192        192   0.6800000
## 6212155       155        155   0.6400000
## 6220135       135        135   1.0000000
## 6221150       150        150   1.0000000
## 6242100       100        100   1.0000000
## 6243110       110        110   0.5200000
## 6253110       110        110   0.8000000
## 6264110       110        110   0.8800000
## 6277115       115        115   1.0000000
## 6279200       200        200   1.0000000
## 6280155       155        155   0.9600000
## 6281135       135        135   1.0000000
## 6298110       110        110   1.0000000
## 6300190       190        190   0.6400000
## 6317155       155        160   0.6800000
## 6325100       100        100   1.0000000
## 6331155       155        161   0.5600000
## 6339161       161        161   0.8400000
## 6345115       115        115   1.0000000
## 6348101       101        101   0.9000000
## 6350160       160        160   1.0000000
## 6352120       120        120   1.0000000
## 6358135       135        135   1.0000000
## 6362161       161        161   1.0000000
## 6382115       115        115   0.9000000
## 6392161       161        161   1.0000000
## 6394150       150        150   1.0000000
## 6398160       160        160   1.0000000
## 6400101       101        101   0.8800000
## 6402200       200        200   1.0000000
## 6432130       130        130   1.0000000
## 6445110       110        110   1.0000000
## 6447190       190        110   0.6000000
## 6462115       115        115   0.9800000
## 6475160       160        160   0.9600000
## 6477200       200        200   1.0000000
## 6481100       100        100   1.0000000
## 6489110       110        110   0.9000000
## 6501105       105        105   1.0000000
## 6503130       130        130   1.0000000
## 6508200       200        200   1.0000000
## 6510110       110        110   0.9800000
## 6517150       150        150   1.0000000
## 6539103       103        103   1.0000000
## 6549115       115        115   1.0000000
## 6553160       160        160   0.9600000
## 6574130       130        130   1.0000000
## 6575161       161        161   1.0000000
## 6590105       105        105   1.0000000
## 6597115       115        115   1.0000000
```

```
## 6601160       160         150   0.9400000
## 6603135       135         135   1.0000000
## 6616101       101         192   0.5400000
## 6624110       110         110   0.9000000
## 6626120       120         120   1.0000000
## 6643155       155         160   0.7000000
## 6664120       120         120   0.9400000
## 6666100       100         100   1.0000000
## 6674130       130         130   1.0000000
## 6676161       161         161   0.8200000
## 6679161       161         161   1.0000000
## 6695200       200         200   1.0000000
## 6702161       161         161   1.0000000
## 6721120       120         120   1.0000000
## 6737120       120         115   0.6400000
## 6768100       100         100   1.0000000
## 6773161       161         161   1.0000000
## 6776115       115         115   1.0000000
## 6777130       130         130   0.9800000
## 6784150       150         150   1.0000000
## 6792100       100         100   0.9200000
## 6800115       115         115   0.9600000
## 6802161       161         161   1.0000000
## 6819110       110         110   1.0000000
## 6828155       155         155   0.7000000
## 6832161       161         161   1.0000000
## 6871135       135         135   1.0000000
## 6882110       110         110   0.5400000
## 6885100       100         100   0.9800000
## 6893200       200         200   0.7400000
## 6921161       161         161   1.0000000
## 6922103       103         103   1.0000000
## 6937161       161         161   1.0000000
## 6960161       161         161   0.9800000
## 6978103       103         103   1.0000000
## 7019100       100         100   1.0000000
## 7023110       110         110   1.0000000
## 7039161       161         161   1.0000000
## 7045101       101         101   0.6000000
## 7050103       103         103   1.0000000
## 7054160       160         160   0.9200000
## 7055192       192         110   0.5200000
## 7057200       200         200   1.0000000
## 7073100       100         100   1.0000000
## 7080150       150         150   1.0000000
## 7081115       115         115   1.0000000
## 7083101       101         101   0.8600000
## 7086161       161         161   1.0000000
## 7093130       130         130   1.0000000
## 7094115       115         115   1.0000000
## 7132130       130         130   1.0000000
## 7140100       100         100   1.0000000
## 7155103       103         103   1.0000000
## 7163135       135         135   1.0000000
## 7164150       150         150   0.8800000
## 7174155       155         155   0.6200000
## 7175110       110         110   0.7000000
## 7177100       100         100   1.0000000
```

```
## 7189160       160         160   1.0000000
## 7193150       150         150   1.0000000
## 7201110       110         110   0.9600000
## 7202105       105         101   0.6000000
## 7204160       160         160   0.8200000
## 7206155       155         155   0.8000000
## 7215150       150         150   1.0000000
## 7219155       155         160   0.9600000
## 7234120       120         120   1.0000000
## 7237110       110         110   1.0000000
## 7241103       103         103   0.4800000
## 7244101       101         101   0.5200000
## 7249135       135         135   1.0000000
## 7251135       135         135   1.0000000
## 7255100       100         100   1.0000000
## 7262115       115         115   1.0000000
## 7275135       135         135   1.0000000
## 7292192       192         101   0.6400000
## 7300155       155         155   0.7400000
## 7310130       130         130   1.0000000
## 7328161       161         161   1.0000000
## 7360150       150         150   0.9215686
## 7382115       115         115   0.8400000
## 7389105       105         105   0.6800000
## 7409150       150         150   1.0000000
## 7411155       155         160   0.6200000
## 7441103       103         103   1.0000000
## 7448130       130         130   1.0000000
## 7449155       155         155   0.5800000
## 7451161       161         161   1.0000000
## 7459100       100         100   1.0000000
## 7468130       130         130   1.0000000
## 7476135       135         135   1.0000000
## 7479150       150         150   1.0000000
## 7484160       160         160   1.0000000
## 7497192       192         192   0.5400000
## 7502135       135         135   1.0000000
## 7522100       100         100   1.0000000
## 7527160       160         160   0.9800000
## 7529130       130         130   1.0000000
## 7532135       135         135   1.0000000
## 7539115       115         115   0.8000000
## 7558103       103         103   1.0000000
## 7561161       161         161   0.9400000
## 7572160       160         150   0.5800000
## 7575115       115         115   1.0000000
## 7576135       135         135   1.0000000
## 7587160       160         160   0.7600000
## 7594110       110         110   0.8200000
## 7604100       100         100   1.0000000
## 7607192       192         150   0.7000000
## 7610130       130         130   1.0000000
## 7635160       160         160   1.0000000
## 7638110       110         110   1.0000000
## 7642100       100         100   1.0000000
## 7645130       130         130   1.0000000
## 7659192       192         101   0.6000000
## 7662161       161         161   0.8400000
```

```
## 7673161       161        161   1.0000000
## 7675110       110        110   1.0000000
## 7679115       115        155   0.5400000
## 7706155       155        155   0.3600000
## 7707100       100        100   1.0000000
## 7712135       135        135   1.0000000
## 7737110       110        110   0.7800000
## 7748120       120        120   0.9800000
## 7749105       105        105   1.0000000
## 7754115       115        120   0.7400000
## 7762161       161        161   0.9400000
## 7767160       160        160   0.9800000
## 7775150       150        150   1.0000000
## 7785120       120        120   1.0000000
## 7790120       120        120   0.8000000
## 7797155       155        155   0.9000000
## 7799160       160        160   0.9400000
## 7807115       115        115   1.0000000
## 7809160       160        160   0.7200000
## 7819135       135        135   0.9400000
## 7822200       200        200   1.0000000
## 7823100       100        100   1.0000000
## 7837110       110        110   0.8200000
## 7838192       192        192   0.6800000
## 7853200       200        200   1.0000000
## 7854103       103        103   1.0000000
## 7857101       101        101   1.0000000
## 7892110       110        110   1.0000000
## 7896130       130        130   1.0000000
## 7902135       135        135   1.0000000
## 7909110       110        110   0.6200000
## 7914161       161        161   1.0000000
## 7918110       110        110   0.9600000
## 7924105       105        105   1.0000000
## 7936130       130        130   1.0000000
## 7969150       150        150   1.0000000
## 7984192       192        192   0.4200000
## 7990160       160        160   0.7000000
## 8006150       150        150   1.0000000
## 8013120       120        120   1.0000000
## 8016115       115        115   0.9800000
## 8023110       110        130   0.5600000
## 8025100       100        100   1.0000000
## 8031100       100        100   1.0000000
## 8042135       135        135   1.0000000
## 8053161       161        155   0.7200000
## 8058192       192        101   0.5800000
## 8073115       115        115   0.7400000
## 8085120       120        120   1.0000000
## 8086200       200        200   1.0000000
## 8115190       190        190   0.9400000
## 8131130       130        130   1.0000000
## 8132103       103        103   1.0000000
## 8133103       103        103   1.0000000
## 8136115       115        115   1.0000000
## 8154192       192        192   0.5800000
## 8163200       200        200   1.0000000
## 8174101       101        110   0.3200000
```

```
## 8175135       135        135   1.0000000
## 8178161       161        161   1.0000000
## 8197160       160        160   1.0000000
## 8198115       115        115   0.8600000
## 8202161       161        161   1.0000000
## 8206100       100        105   0.5400000
## 8210161       161        161   1.0000000
## 8220150       150        150   1.0000000
## 8227120       120        120   1.0000000
## 8244160       160        160   1.0000000
## 8247160       160        160   0.8000000
## 8256100       100        100   1.0000000
## 8261155       155        161   0.4000000
## 8262100       100        100   1.0000000
## 8265120       120        120   1.0000000
## 8268135       135        135   1.0000000
## 8277155       155        155   0.5400000
## 8292160       160        160   0.9400000
## 8297150       150        150   1.0000000
## 8305135       135        135   1.0000000
## 8306110       110        110   0.7000000
## 8308130       130        130   0.9800000
## 8323110       110        110   0.7800000
## 8326161       161        161   1.0000000
## 8340100       100        100   1.0000000
## 8348150       150        150   1.0000000
## 8352100       100        100   1.0000000
## 8356192       192        192   0.6200000
## 8358160       160        160   0.9400000
## 8364192       192        155   0.3000000
## 8382103       103        103   1.0000000
## 8384120       120        120   0.8400000
## 8387200       200        200   1.0000000
## 8399155       155        155   0.6800000
## 8403135       135        135   1.0000000
## 8405130       130        130   1.0000000
## 8421155       155        155   0.5400000
## 8424110       110        110   0.5200000
## 8440120       120        120   1.0000000
## 8442103       103        103   1.0000000
## 8445150       150        161   0.5000000
## 8464150       150        150   0.6400000
## 8468110       110        110   1.0000000
## 8476155       155        155   1.0000000
## 8494150       150        150   1.0000000
## 8509115       115        115   1.0000000
## 8515100       100        100   1.0000000
## 8527150       150        150   1.0000000
## 8531192       192        192   0.7600000
## 8541192       192        101   0.8600000
## 8544105       105        105   1.0000000
## 8554190       190        190   0.7254902
## 8566161       161        161   1.0000000
## 8569100       100        100   1.0000000
## 8571150       150        150   1.0000000
## 8581135       135        135   1.0000000
## 8603103       103        103   1.0000000
## 8606100       100        100   1.0000000
```

```
## 8628120       120        120   0.8200000
## 8637155       155        155   0.8400000
## 8646110       110        110   0.5600000
## 8663120       120        120   1.0000000
## 8670150       150        150   1.0000000
## 8684130       130        130   1.0000000
## 8687192       192        192   1.0000000
## 8717110       110        110   0.8200000
## 8718155       155        160   0.6800000
## 8724161       161        161   1.0000000
## 8727161       161        161   1.0000000
## 8732155       155        155   0.7000000
## 8735100       100        100   1.0000000
## 8738160       160        160   1.0000000
## 8760161       161        161   1.0000000
## 8762100       100        100   1.0000000
## 8771105       105        105   1.0000000
## 8778150       150        150   1.0000000
## 8785135       135        135   1.0000000
## 8790115       115        115   0.9400000
## 8803103       103        103   1.0000000
## 8806135       135        135   1.0000000
## 8809130       130        130   1.0000000
## 8810160       160        160   1.0000000
## 8819101       101        101   1.0000000
## 8824105       105        105   1.0000000
## 8830160       160        160   1.0000000
## 8833200       200        200   1.0000000
## 8837105       105        105   1.0000000
## 8839103       103        103   1.0000000
## 8846110       110        110   1.0000000
## 8851110       110        110   0.9800000
## 8885101       101        101   1.0000000
## 8889130       130        130   1.0000000
## 8926161       161        161   0.9800000
## 8929135       135        135   1.0000000
## 8936160       160        160   1.0000000
## 8940100       100        100   1.0000000
## 8947155       155        161   0.6200000
## 8961103       103        103   1.0000000
## 8973130       130        130   1.0000000
## 8979135       135        135   1.0000000
## 8981190       190        190   0.7800000
## 9013115       115        115   0.9600000
## 9033130       130        130   0.8800000
## 9034110       110        110   0.7600000
## 9053135       135        135   1.0000000
## 9062100       100        100   1.0000000
## 9077160       160        160   0.9600000
## 9078120       120        101   0.8600000
## 9079161       161        161   1.0000000
## 9083160       160        160   0.9200000
## 9087150       150        150   1.0000000
## 9089130       130        130   0.9400000
## 9117101       101        101   0.7600000
## 9125103       103        103   1.0000000
## 9135135       135        135   1.0000000
## 9144150       150        150   1.0000000
```

```
## 9145135       135        135   1.0000000
## 9159120       120        120   0.8800000
## 9165120       120        115   0.6000000
## 9175150       150        150   1.0000000
## 9177100       100        100   0.9800000
## 9188130       130        101   0.3000000
## 9189110       110        110   0.9000000
## 9207130       130        130   1.0000000
## 9210130       130        150   0.5000000
## 9213120       120        120   1.0000000
## 9214161       161        161   1.0000000
## 9219161       161        161   1.0000000
## 9220120       120        120   0.9400000
## 9223161       161        161   0.8600000
## 9235135       135        135   1.0000000
## 9254150       150        150   1.0000000
## 9262150       150        150   1.0000000
## 9263103       103        103   1.0000000
## 9264120       120        120   0.8400000
## 9272120       120        120   1.0000000
## 9275120       120        120   0.7600000
## 9276150       150        150   1.0000000
## 9278155       155        155   0.9400000
## 9292100       100        100   1.0000000
## 9316115       115        115   1.0000000
## 9328150       150        150   1.0000000
## 9331160       160        160   0.9800000
## 9335135       135        135   1.0000000
## 9362150       150        150   1.0000000
## 9406130       130        130   1.0000000
## 9408115       115        115   1.0000000
## 9422101       101        100   0.8600000
## 9427115       115        115   1.0000000
## 9434192       192        192   0.5600000
## 9436120       120        120   1.0000000
## 9475105       105        105   0.7600000
## 9476120       120        110   0.3400000
## 9505120       120        120   0.8800000
## 9508105       105        105   0.6600000
## 9514101       101        101   0.9800000
## 9518115       115        115   1.0000000
## 9540100       100        100   1.0000000
## 9541120       120        120   1.0000000
## 9545150       150        150   1.0000000
## 9566115       115        115   1.0000000
## 9573103       103        103   1.0000000
## 9574130       130        130   1.0000000
## 9582160       160        160   1.0000000
## 9586120       120        120   1.0000000
## 9600103       103        103   1.0000000
## 9603160       160        160   0.9400000
## 9604160       160        160   0.9400000
## 9613103       103        103   1.0000000
## 9614130       130        130   1.0000000
## 9619192       192        192   0.9000000
## 9626110       110        110   1.0000000
## 9662120       120        120   1.0000000
## 9666135       135        135   1.0000000
```

```
## 9667115       115         115   1.0000000
## 9669160       160         160   0.8800000
## 9670103       103         103   1.0000000
## 9689190       190         190   0.7000000
## 9696161       161         161   0.8000000
## 9702150       150         150   1.0000000
## 9704155       155         155   0.8600000
## 9709155       155         155   0.5200000
## 9715155       155         155   0.7200000
## 9718130       130         130   1.0000000
## 9729200       200         200   1.0000000
## 9746150       150         150   1.0000000
## 9748155       155         155   0.6800000
## 9749103       103         103   1.0000000
## 9755120       120         120   0.9800000
## 9756101       101         192   0.6000000
## 9757130       130         130   1.0000000
## 9768115       115         115   1.0000000
## 9773161       161         161   1.0000000
## 9775120       120         120   1.0000000
## 9781101       101         101   1.0000000
## 9784155       155         155   0.9400000
## 9787135       135         135   1.0000000
## 9806192       192         192   0.5600000
## 9811101       101         101   0.9400000
## 9812161       161         161   0.9400000
## 9822103       103         103   0.9200000
## 9824135       135         135   1.0000000
## 9825103       103         100   1.0000000
## 9833130       130         130   1.0000000
## 9858115       115         115   0.6800000
## 9875130       130         130   0.9800000
## 9880135       135         135   1.0000000
## 9908100       100         100   1.0000000
## 9918105       105         101   0.6400000
## 9919115       115         115   1.0000000
## 9921130       130         130   1.0000000
## 9940135       135         135   1.0000000
## 9942120       120         120   0.6800000
## 9960100       100         100   1.0000000
## 9970110       110         110   0.7400000
## 9975160       160         160   0.9400000
## 10003155      155         155   0.9800000
## 10004115      115         115   0.9600000
## 10006135      135         135   1.0000000
## 10011200      200         200   1.0000000
## 10014100      100         100   1.0000000
## 10025101      101         101   0.5800000
## 10042115      115         120   1.0000000
## 10082103      103         103   1.0000000
## 10083200      200         200   1.0000000
## 10096150      150         150   1.0000000
## 10098130      130         130   1.0000000
## 10114130      130         130   1.0000000
## 10116155      155         155   0.5600000
## 10123190      190         190   0.8000000
## 10135155      155         155   0.6800000
## 10152135      135         135   1.0000000
```

```
## 10154155      155        155   0.8000000
## 10195155      155        155   0.8800000
## 10197150      150        150   0.8800000
## 10205130      130        130   1.0000000
## 10209192      192        192   0.6600000
## 10213135      135        135   1.0000000
## 10226103      103        103   1.0000000
## 10231150      150        150   1.0000000
```

Tratamiento por zonas de muestreo (test)

```
# rearrange data to data.frame
# create empty dataframe
control_sampling_df <- data.frame(matrix(ncol = raster_layers_count + 1, nrow = 0))
colnames(control_sampling_df) <- c(raster_layers_names,"ZN")

# take every list unit and put it into dataframe, the extra column is for index
for (i in 1:length(control_sampling)) {
  c_length <- dim(control_sampling[[i]])[1]
  id <- control_parcels@data$Id[i]
  fl <- cbind(control_sampling[[i]], ZN = rep(id,c_length))
  control_sampling_df <- rbind(control_sampling_df,fl)
}

# resumen of data per parcel
for (i in 1:length(control_sampling)) {
  if (verbose) {
    # get parcel id
    parcel_id <- control_parcels@data$Id[i]
    cat("Parcela de control: ", as.character(parcel_id),"\n")
    cat("Clase original: ",control_parcels@data$Code_2[i],"\n")
    # subset dataframe on parcel id
    df_selection <- control_sampling_df[control_sampling_df$ZN == parcel_id,c(1:8)]
    # get summary
    cat("Resumen","\n")
    #print(summary(df_selection))
    boxplot(df_selection, col = "lightgray")
    cat("\n\n")
  }
}

# optional standardize variables (only data columns)
# control_sampling_df[,c(1:raster_layers_count)] <- scale(control_sampling_df[,c(1:raster_lay
ers_count)])

M2 <-aggregate( . ~ ZN, data = control_sampling_df, FUN = mean)
row.names(M2) <- M2$ZN
raster_layers_count1 <- raster_layers_count + 1
M2 <- M2[,c(2:raster_layers_count1)]
M2
```

```
##         pc1      pc2      pc3      pc4      pc5      pc6      pc7      pc8
## 0  47308.77 29085.91 19163.39 51119.87 18062.19 24326.99 22829.84 25388.83
## 1  49269.58 29485.53 20040.02 51232.92 18116.91 24448.50 22848.52 25466.72
## 2  39042.96 30080.34 19102.90 51708.31 17961.04 24627.67 23210.57 25371.07
## 3  34594.71 27920.68 22835.90 51420.00 17939.53 24293.90 23193.68 25103.56
## 4  47603.79 23913.97 31609.64 53192.29 18326.76 23218.52 22843.87 25313.64
## 5  60327.16 34418.49 18984.79 50434.81 18243.29 25363.64 23235.63 25782.14
## 6  39743.70 25644.29 32129.24 52651.92 18170.61 24166.70 22030.14 25164.85
## 7  55345.96 23159.52 19422.27 51509.74 18442.42 25420.36 22517.60 25416.27
## 8  55056.58 22043.50 20758.32 51436.58 18503.53 24366.01 23375.51 25369.55
## 9  38275.09 25965.71 22387.23 51602.93 19112.27 24622.73 23133.62 25824.54
## 10 37538.19 25798.38 22203.05 51139.88 18739.45 24891.40 23304.68 25570.79
## 11 39614.83 25779.88 18645.33 52621.30 17919.48 24576.86 23121.87 25342.68
## 12 39013.84 26632.30 15703.51 48111.80 19295.28 23884.87 21221.16 26488.96
## 13 62983.41 30012.55 19624.73 52270.31 18917.73 24267.55 22510.21 26011.76
## 14 40155.24 24754.33 22953.68 51445.08 18659.45 25106.77 23348.01 25781.06
## 15 54531.27 22298.05 21131.53 52682.46 19015.67 24387.55 23281.30 25544.35
## 16 43131.71 24778.42 19017.82 52459.94 18470.09 24499.13 23327.99 25493.62
## 17 65737.94 27701.47 20435.84 53153.42 18837.72 24135.55 22406.54 25886.45
## 18 40033.52 25105.81 22369.52 51397.72 18924.04 25132.30 23050.29 25998.85
## 19 52023.80 24592.03 18578.12 50519.60 18291.60 24129.37 22179.94 25211.69
## 20 49658.89 23320.96 19465.75 51517.91 18430.38 25161.22 24231.00 25291.22
## 21 43794.84 24177.39 21318.82 50613.87 19117.71 24947.40 23324.48 25932.96
## 22 45888.27 25301.97 18826.75 52513.29 18667.49 24615.43 23995.99 25552.47
## 23 46588.10 25912.39 21711.61 51509.00 17968.03 25125.15 22407.68 24980.65
## 24 51233.40 23129.36 21981.47 54700.54 18041.52 24594.94 22952.68 25674.02
## 25 48422.30 23386.46 19226.13 52534.48 18861.94 24331.70 23346.81 25508.55
## 26 43232.58 24401.96 17678.88 51900.14 18453.86 24437.41 23374.56 25409.05
## 27 48477.39 23486.34 18024.25 51572.98 18444.59 24641.36 23598.84 25527.92
## 28 42543.75 24525.98 20718.52 50970.03 19078.58 25440.98 22722.15 25817.63
## 29 47618.96 24731.55 18965.73 52830.84 18266.66 24354.49 23001.33 25491.31
## 30 22539.47 31721.00 16007.33 52393.01 17624.80 24906.09 23847.75 25205.80
## 31 43321.15 23791.11 19329.76 49400.55 19024.64 25004.41 23445.74 25652.66
## 32 40980.17 25566.53 22519.30 51980.22 18677.10 24956.31 23008.12 25859.24
## 33 38961.28 26175.53 18432.95 52489.54 18546.36 24733.65 22989.32 25726.10
## 34 37962.44 26005.99 24738.91 52901.39 18351.44 24190.27 23060.50 25444.11
## 35 44102.80 24922.50 29154.53 54114.96 18632.44 23421.22 22630.82 25415.10
## 36 31052.74 31542.99 17152.48 52975.40 18167.64 25016.03 23808.84 25429.08
## 37 45183.14 23058.43 17663.13 52548.07 18467.95 24727.66 23840.30 25471.20
## 38 29788.80 30610.58 19036.44 52551.82 17893.82 24646.80 23704.06 25222.66
## 39 46567.16 30073.15 18874.14 51329.67 18018.01 24533.19 22977.73 25499.91
## 40 35841.55 27357.77 17941.22 53554.62 18310.84 24611.59 23099.81 25641.15
## 41 36536.76 28209.48 22273.83 52917.03 18378.74 24180.33 23170.58 25675.06
## 42 41510.86 25048.34 18873.87 51991.57 18549.85 24685.17 22903.12 25578.70
## 43 44374.90 23588.01 19904.10 49571.77 19116.29 25144.68 23385.98 25767.94
## 44 52658.27 24325.31 19552.70 54456.89 18997.43 24117.19 22665.76 25885.96
## 45 45025.18 23718.01 18203.37 52173.45 18512.43 24549.29 23302.96 25638.91
## 46 54716.25 29098.87 20354.41 50996.00 18278.01 24429.04 22888.38 25415.66
## 47 49214.87 24462.74 17811.95 53399.98 18096.87 24171.50 22265.15 25718.34
## 48 44392.17 25122.44 18272.33 51518.57 18285.42 24748.95 23441.97 25394.96
## 49 37068.96 32341.65 17967.83 52565.83 17629.20 25093.82 23701.98 25310.35
## 50 47273.67 24254.03 18032.22 51340.71 18263.70 24833.54 23854.34 25334.28
## 51 38955.87 25314.71 23757.08 52286.53 18711.76 25011.09 23185.42 25831.27
## 52 50064.52 32281.21 18733.48 53067.11 18650.39 25044.66 23397.91 25922.02
## 53 50389.85 22908.96 22486.12 52294.72 18784.21 24422.62 23370.85 25449.19
## 54 43628.02 24207.81 21083.13 52244.56 18524.94 25121.08 22821.60 25659.93
## 55 48091.98 24127.51 19623.70 51279.23 18302.60 25007.53 23374.12 25441.69
```

```
## 56 56135.35 23280.95 20096.89 52473.81 18570.67 24539.27 22392.77 25571.97
## 57 40300.34 24345.35 20259.61 51523.77 18424.76 25641.13 22935.79 25527.62
## 58 42732.45 26234.75 22696.22 52384.79 18964.24 24380.35 22810.45 25751.37
## 59 58843.72 25178.51 19168.00 51921.09 17682.60 23856.83 22335.27 24611.64
## 60 51722.79 22364.25 20338.31 51990.40 18818.60 24721.61 23480.09 25521.29
## 61 41908.90 25621.88 21100.09 52368.37 19180.59 24591.59 23069.09 25825.70
## 62 38247.72 25642.75 18559.53 52304.03 17566.10 24904.62 23424.64 25287.52
## 63 45064.19 25443.84 21420.03 53639.46 18082.91 25484.52 23506.00 25493.22
## 64 35301.68 29574.10 18735.65 52988.64 18896.58 24241.98 22971.66 25708.54
## 65 42075.99 25019.24 24803.43 53541.14 18269.29 23878.33 22899.74 25548.48
## 66 52102.98 25433.35 18271.06 49475.70 18421.25 23755.49 21808.40 25264.85
## 67 52048.12 24935.65 18815.44 52113.55 18198.66 24749.77 22143.86 25440.60
## 68 45832.92 29618.25 19102.74 52790.18 17791.19 24577.91 23595.88 25369.02
## 69 51720.93 29508.00 19576.45 51487.03 18021.32 24544.99 22954.31 25460.20
## 70 40997.74 24488.30 35653.79 54237.54 17938.18 24557.66 20769.49 25225.41
```

Determinar clase mas probable para cada zona de muestreo complementario (K-nearets neighbour)

```
# the order of elements in results of "aggregate" is not the same as in the original class,
# so it is necessary to sort the class labels in same order as training set
# following is to get original class label vector with same order as elements in M2
control_sampling_classes <- c()
M2_length <- dim(M2)[1]
for (i in 1:M2_length) {
  zone_code <- row.names(M2[i,])
  zone_subset <- control_parcels[control_parcels@data$Id == zone_code,]
  zone_class <- zone_subset@data$Code_2
  if (verbose) {
    cat("Zona: ", zone_code,"\n")
    cat("Clase de zona: ", zone_class, "\n")
  }
  control_sampling_classes <- c(control_sampling_classes, zone_class)
}

# check the dataset dimensions
#dim(main_sampling_df[,c(1:raster_layers_count)])
#dim(M2)
#length(main_sampling_df[,"CL"])

# Predict the most probable class for each parcel
prediction_M2 <- knn(main_sampling_df[,c(1:8)], # training set
                  M2,                          # test set
                  main_sampling_df[,"CL"],   # training class labels
                  k = 50, prob = TRUE)

M2_predict <- cbind(M2, prediction = prediction_M2, probability = attr(prediction_M2,
"prob"), original = control_sampling_classes)
table_M2_predict <- M2_predict[,c("original","prediction","probability")]
write.csv(table_M2_predict,file = "tabla_M2_predict.csv")
```

Tabla con valores de predicción para cada zona de muestreo complementario

```
table_M2_predict
```

```
##    original prediction probability
## 0       100        100    1.000000
## 1       100        100    1.000000
## 2       103        103    1.000000
## 3       192        192    0.980000
## 4       190        190    0.720000
## 5       100        105    0.620000
## 6       190        190    0.780000
## 7       120        115    0.800000
## 8       120        120    0.960000
## 9       160        161    0.500000
## 10      160        160    1.000000
## 11      150        150    1.000000
## 12      120        120    1.000000
## 13      105        105    1.000000
## 14      161        161    1.000000
## 15      115        120    0.620000
## 16      135        135    0.960000
## 17      105        105    1.000000
## 18      161        161    1.000000
## 19      115        115    1.000000
## 20      120        120    0.820000
## 21      161        161    1.000000
## 22      135        130    0.900000
## 23      110        110    0.540000
## 24      115        115    0.660000
## 25      130        130    0.900000
## 26      135        135    1.000000
## 27      120        130    1.000000
## 28      150        161    1.000000
## 29      120        130    1.000000
## 30      200        200    1.000000
## 31      161        161    0.800000
## 32      192        161    0.840000
## 33      150        150    1.000000
## 34      155        155    0.920000
## 35      190        110    0.440000
## 36      200        200    0.745098
## 37      135        135    0.960000
## 38      200        200    1.000000
## 39      100        100    1.000000
## 40      150        150    1.000000
## 41      155        155    0.460000
## 42      150        150    1.000000
## 43      161        161    1.000000
## 44      120        115    0.820000
## 45      135        135    1.000000
## 46      105        105    0.760000
## 47      120        115    0.480000
## 48      130        135    1.000000
## 49      105        103    1.000000
## 50      120        130    1.000000
## 51      160        161    0.920000
## 52      105        100    1.000000
## 53      120        120    0.580000
## 54      135        161    1.000000
## 55      120        120    0.680000
```

```
## 56      120        115    0.940000
## 57      160        150    0.700000
## 58      192        130    0.420000
## 59      120        120    0.500000
## 60      120        120    1.000000
## 61      161        161    0.920000
## 62      150        150    1.000000
## 63      120        130    1.000000
## 64      200        150    0.500000
## 65      110        155    0.580000
## 66      120        115    1.000000
## 67      120        115    1.000000
## 68      103        100    1.000000
## 69      101        100    1.000000
## 70      110        190    0.820000
```