

# 589Project

Nowshaba Durrani, Ricky Heinrich, Viji Rajagopalan

2023-04-09

## Libraries

```
#install.packages("mapcan")
#install.packages("bcmaps")
#install.packages("rgbif")

library(rgbif) #allows searching and retrieving data from GBIF
library(ggplot2) #use ggplot2 to add layer for visualization
library(sp) #Standardized Support for Spatial Vector Data
library(sf)
library(spatstat)
library(maptools)
#library(raster)
#library(mapcan)
#library(bcmaps)
#library(tidyverse)
#library(rgdal)

#occ_count() # occurrence count for all the species in GBIF (Global Biodiversity Information Facility) - 

redFox <- name_backbone(name="Vulpes vulpes")
redFoxList <- occ_data(taxonKey = redFox$speciesKey, hasCoordinate=TRUE, stateProvince='British Columbia')
mydata <- redFoxList$data
n_row <- nrow(redFoxList$data)
n_col <- ncol(redFoxList$data)
#n_row
#n_col
```

For our Data 589 project, we have selected Red Fox (Scientific Name - *Vulpes vulpes*) to do the analysis. In the GBIF database they have approximately, 610,958+ georeferences records for this species around the world, however for this project we have selected to do the analysis of the occurrence of Red Fox in BC only. So with the above function we have fetched the information for British Columbia only in 127 columns and 242 number of entries.

```
load("BC_Covariates.Rda")

# Create a spatial points data frame from the longitude and latitude columns
coordinates <- mydata[,c("decimalLongitude", "decimalLatitude")]
dat.sp <- SpatialPointsDataFrame(c(mydata[,c('decimalLongitude', 'decimalLatitude')]), data = mydata)
```

```

# Set the current CRS
proj4string(dat.sp) <- CRS("+proj=longlat +datum=WGS84")

# Define the new CRS you want to transform to
new_crs <- CRS("+proj=aea +lat_0=45 +lon_0=-126 +lat_1=50 +lat_2=58.5 +x_0=1000000
+y_0=0 +datum=NAD83 +units=m +no_defs")

# Transform the data to the new CRS
data.sp_trans <- spTransform(dat.sp, new_crs)

#data_transformed
#data.sp_trans

#plot(data.sp_trans, main = "Locations in BC", cex = 0.8, col ="blue")

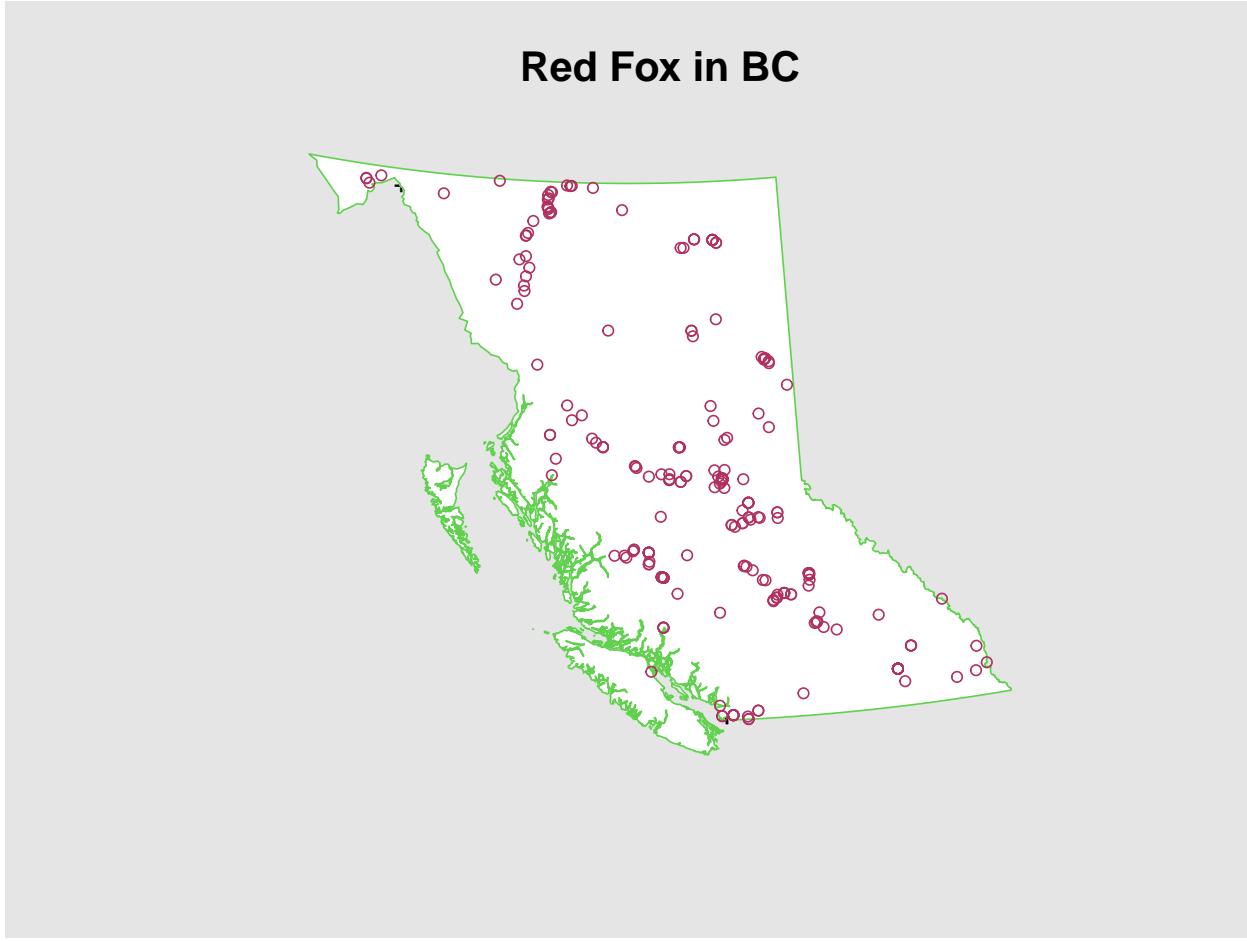
library(sf)
lapply(DATA, FUN = class)

## $Window
## [1] "SpatialPolygons"
## attr(,"package")
## [1] "sp"
##
## $Elevation
## [1] "im"
##
## $Forest
## [1] "im"
##
## $HFI
## [1] "im"
##
## $Dist_Water
## [1] "im"

parks_ppp <- ppp(x = data.sp_trans@coords[,1], # X coordinates
                    y = data.sp_trans@coords[,2], # Y coordinates
                    window = as.owin( DATA[["Window"]]),# Observation window
                    )

col_pal <- c("maroon")
plot(parks_ppp,
      main = "Red Fox in BC",
      cex = 0.9,
      col ="white",
      border = 3,
      cols = col_pal,
      par(bg = "grey90",cex.main = 1.6))

```



Here we have plotted all the occurrences of Red Fox in the BC region and we can see that the species are scattered in the region specially in the upper and middle part of the province. Now we will be exploring what is contributing to the occurrences of the species in the specific places based on various factors like elevation, close to water bodies, forests, human habitats, etc.

### First Moment Analysis

```
#summary(parks_ppp)
intensity(parks_ppp)
```

```
## [1] 2.509854e-10
```

Per the summary, Average intensity  $5.063089 \times 10^{-10}$  points per square unit which is  $0.000000005063089$  per square unit and this does not explain the observance of *Vulpes Vulpes* in a meaningful way.

Quadratcount: 5 by 5 and 10 by 10 - Both convey different view points on the intensity of the observance. According to plot 1, most of the *Vulpes Vulpes* are spotted in the South West areas around Vancouver.

The 10X10 figure shows the intensity is high in the coastal areas with higher density in the South West region.

```

#Split into a 5 by 5 quadrat and count points
Q <- quadratcount(parks_ppp,
                    nx = 5,
                    ny = 5)

#Plot the output
par(mfrow=c(1,2))
plot(parks_ppp,
      pch = 12,
      cex = 0.5,
      cols = "#046C9A",
      main = "Vulpes Vulpes locations")

## Warning in plot.ppp(parks_ppp, pch = 12, cex = 0.5, cols = "#046C9A", main =
## "Vulpes Vulpes locations"): 4 illegal points also plotted

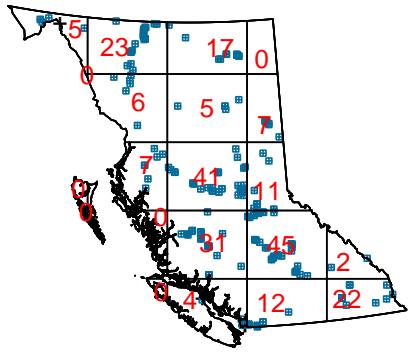
plot(Q, cex = 1, col = "red", add = T)

Q <- quadratcount(parks_ppp,
                    nx = 10,
                    ny = 10)

#Plot the output
par(mfrow=c(1,2))

```

## Vulpes Vulpes locations

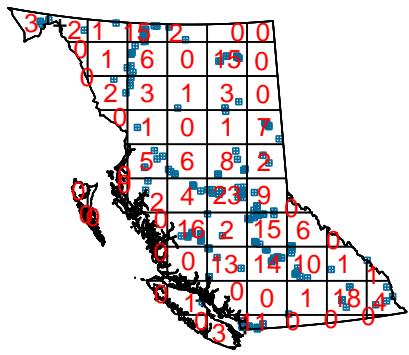


```
plot(parks_ppp,
      pch = 12,
      cex = 0.5,
      cols = "#046C9A",
      main = "Beilschmiedia pendula locations")
```

```
## Warning in plot.ppp(parks_ppp, pch = 12, cex = 0.5, cols = "#046C9A", main =
## "Beilschmiedia pendula locations"): 4 illegal points also plotted
```

```
plot(Q, cex = 1, col = "red", add = T)
```

## Beilschmiedia pendula locations



Quadrat counting suggests varying intensity and to confirm that the variation is not due to chance alone, we conduct an objective test for spatial (in)homogeneity. We do a Chi-square test to validate if the deviations are significant.

```
#Quadrat test of homogeneity  
quadrat.test(Q)
```

```
## Warning: Some expected counts are small; chi^2 approximation may be inaccurate  
  
##  
## Chi-squared test of CSR using quadrat counts  
##  
## data:  
## X2 = 352.69, df = 63, p-value < 2.2e-16  
## alternative hypothesis: two.sided  
##  
## Quadrats: 64 tiles (irregular windows)
```

The null hypothesis of the test suggests homogeneity in the process and as the p-value is very small, the null hypothesis is rejected and its confirmed there is significant deviation from homogeneity.

Hot spot analysis: As the next step, we analyze for any hot spots in the south west coastal areas of BC.

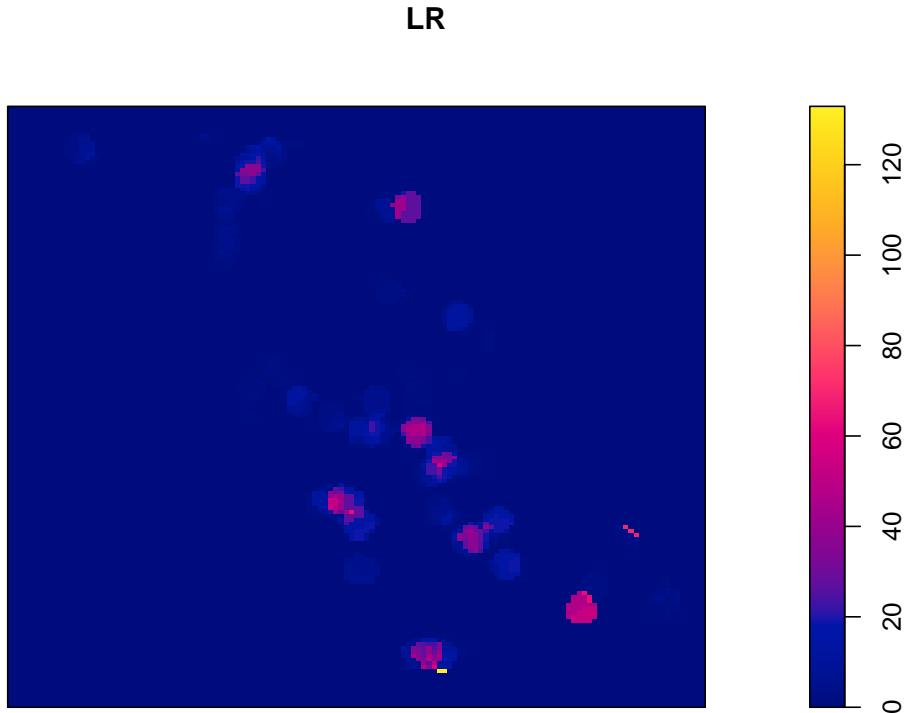
```

# Estimate R
R <- bw.ppl(parks_ppp)

#Calculate test statistic
LR <- scanLRTS(parks_ppp, r = R)

#Plot the output
plot(LR)

```



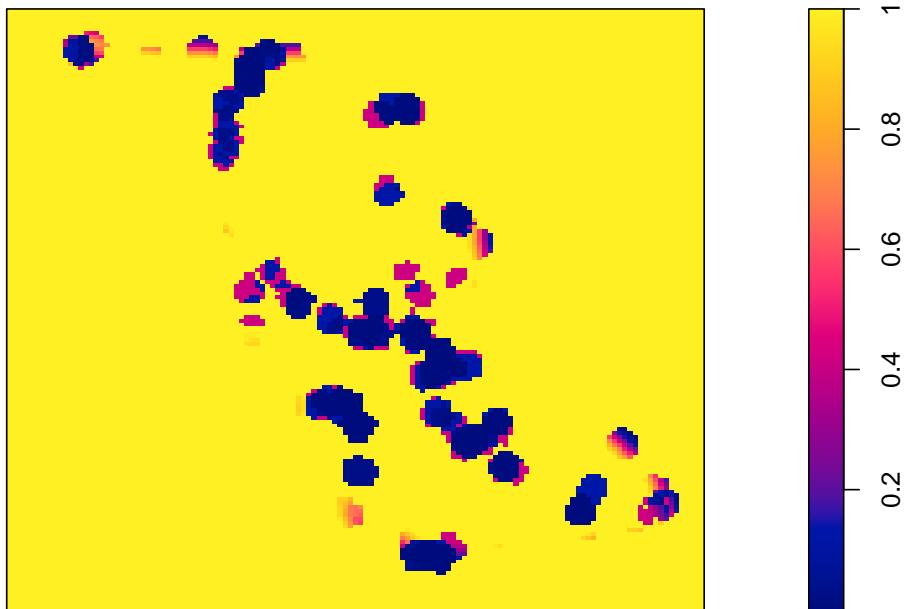
```

#Compute local p-values
pvals <- eval.im(pchisq(LR,
                         df = 1,
                         lower.tail = FALSE))

#Plot the output
plot(pvals, main = "Local p-values")

```

## Local p-values



Question: Do we need p -value intensity analysis? Also, is it possible to add the window for better observation window boundary (shape of BC)?

```
#add marks and relationship with one covariate to start with
parks_ppp <- ppp(x = data.sp_trans$decimalLatitude, # X coordinates
                     y = data.sp_trans$decimalLongitude)

#.....
```

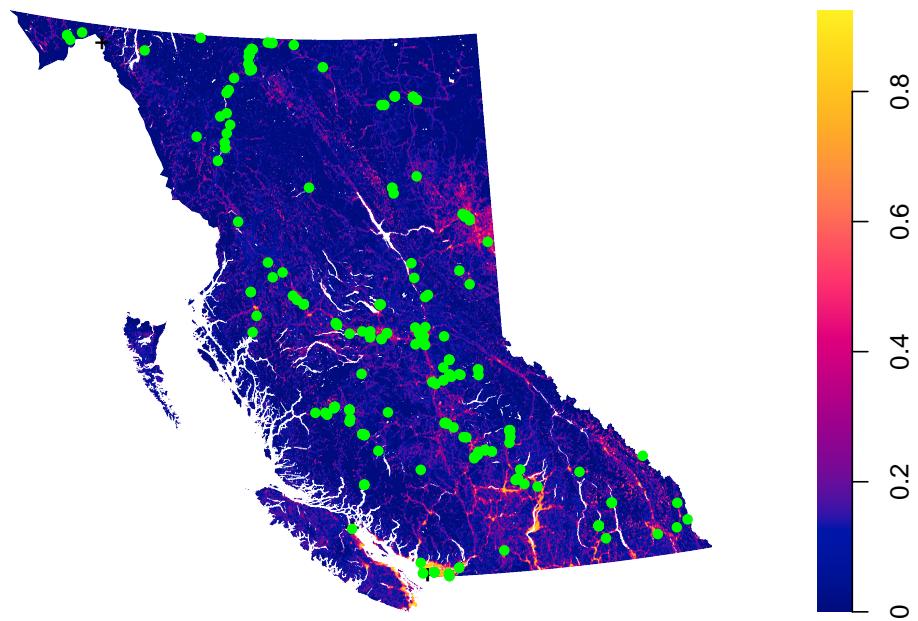
## Covariates Analysis

Our data includes 4 covariates we can explore: the elevation, the forest cover, the human footprint inventory (HFI), and the distance to water. Given our research questions, we will start with investigating the HFI and the forest cover.

### HFI

```
plot(DATA$HFI, box = F, par(cex.main = 2), main = "HFI")
plot(parks_ppp, pch = 16, cex = 0.9, col = "green", use.marks = F, add = T)
```

# HFI

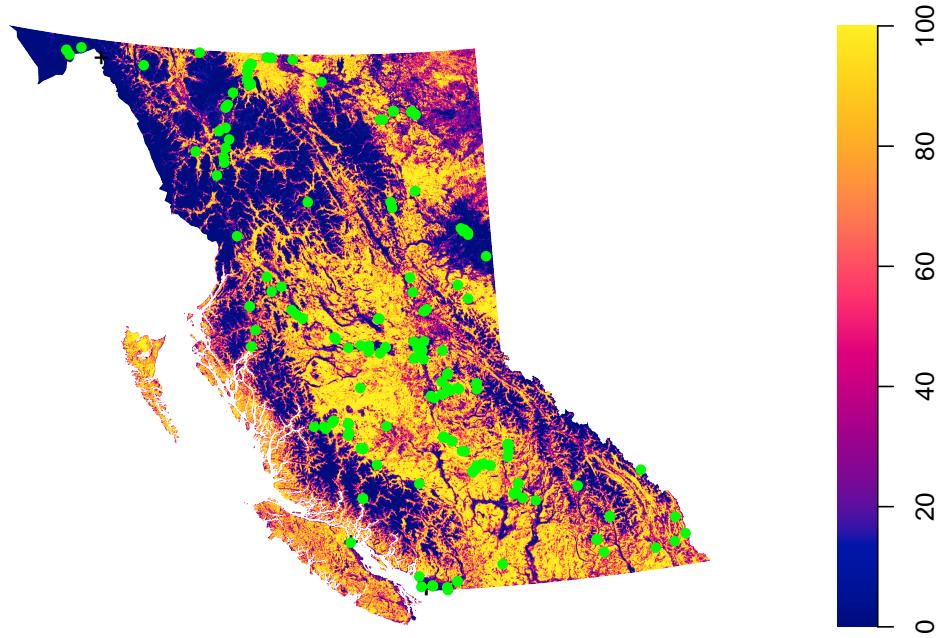


From this plot, it is hard to tell if there is a possible relationship between a red fox occurrence and the HFI.

## Forest Cover

```
plot(DATA$Forest, box = F, par(cex.main = 2), main = "Forest")
plot(parks_ppp, pch = 16, cex = 0.9, col = "green", use.marks = F, add = T)
```

## Forest

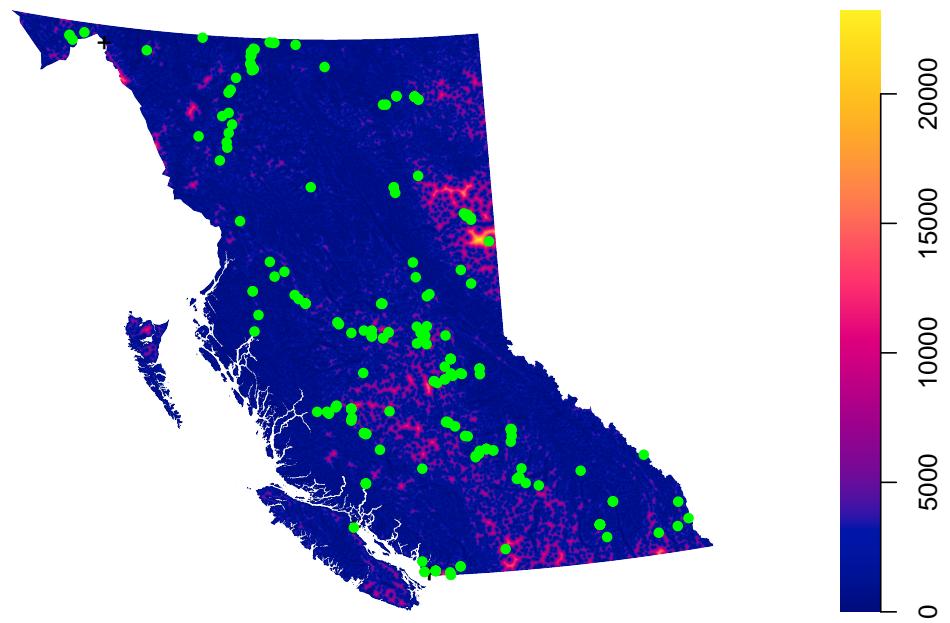


It is also very hard to see if there is a relationship, this time because there are a lot of high values for forest cover all over the province.

### Distance to water

```
plot(DATA$Dist_Water, box = F, par(cex.main = 2), main = "Distance to water")
plot(parks_ppp, pch = 16, cex = 0.9, col = "green", use.marks = F, add = T)
```

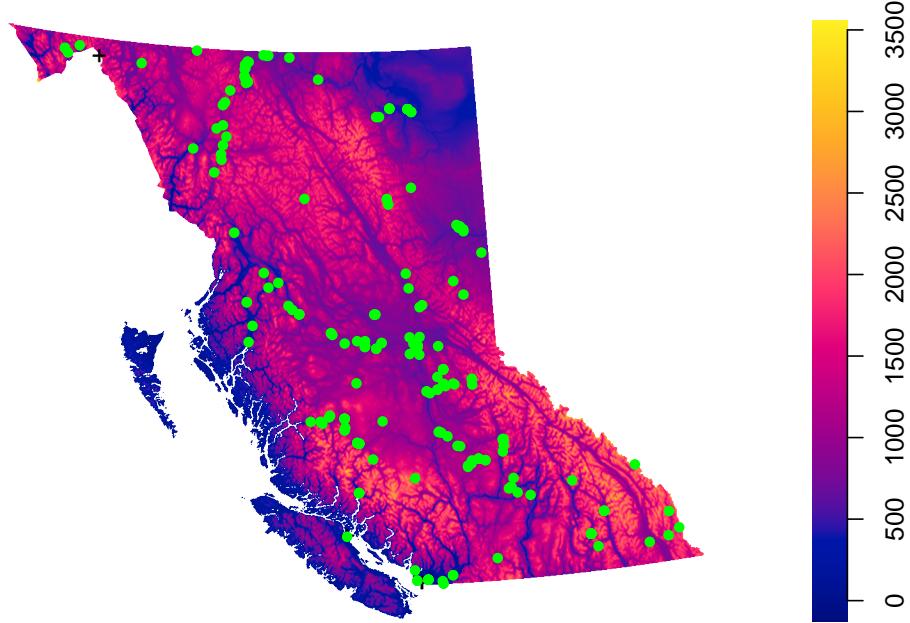
## Distance to water



Elevation

```
plot(DATA$Elevation, box = F, par(cex.main = 2), main = "Elevation")
plot(parks_ppp, pch = 16, cex = 0.9, col = "green", use.marks = F, add = T)
```

# Elevation



Conclusion: maybe need to segment the continuous values of covariates so that it is easier to see trend, like histogram in lab 1.

## 2nd Moment Analysis

### Morisita's Index plot

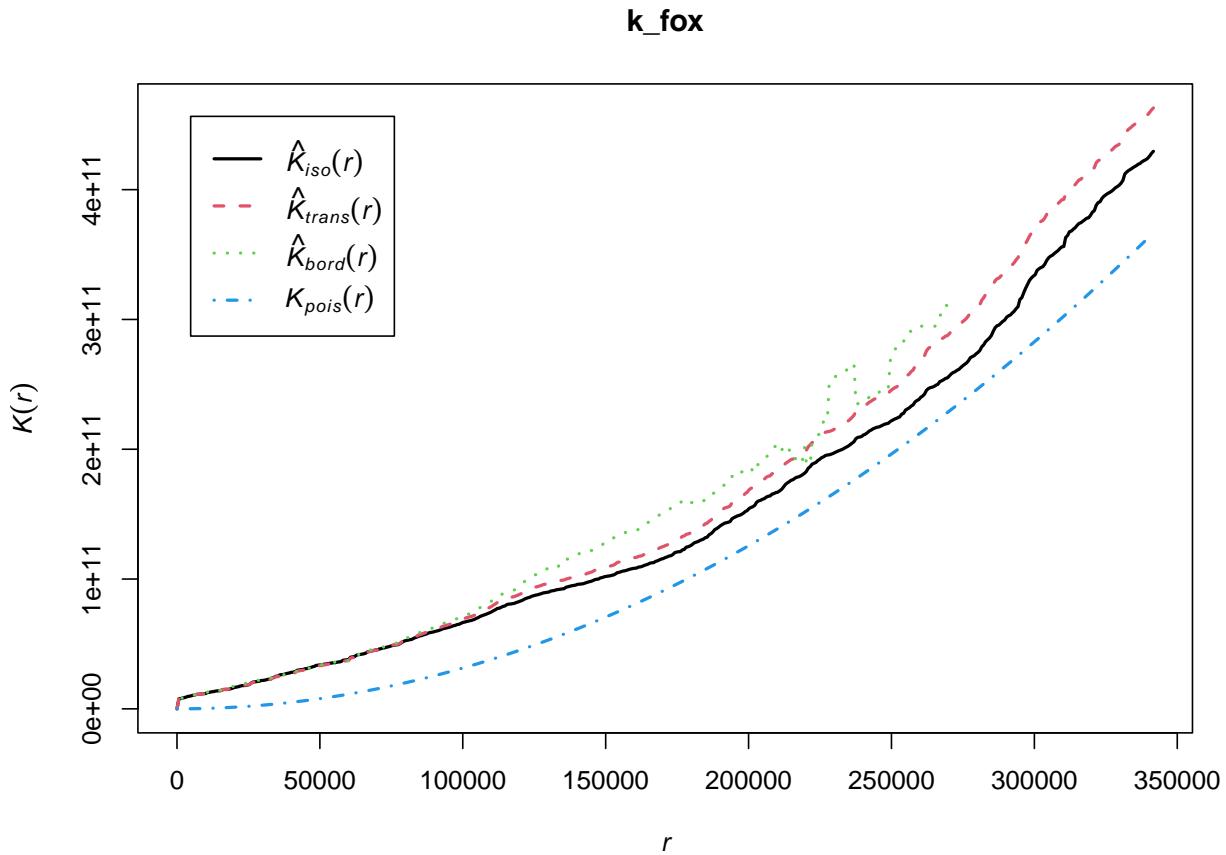
this produces an error, and we don't need to include it

```
miplot(parks_ppp,  
       main = "",  
       pch = 16,  
       col = "maroon")
```

### Ripley's K function

Ripley's K-function provides information on whether there are significant deviations from independence between points.

```
k_fox <- Kest(parks_ppp)  
plot(k_fox, lwd=2)
```



The blue line is the theoretical line. (I don't know what the other lines mean)

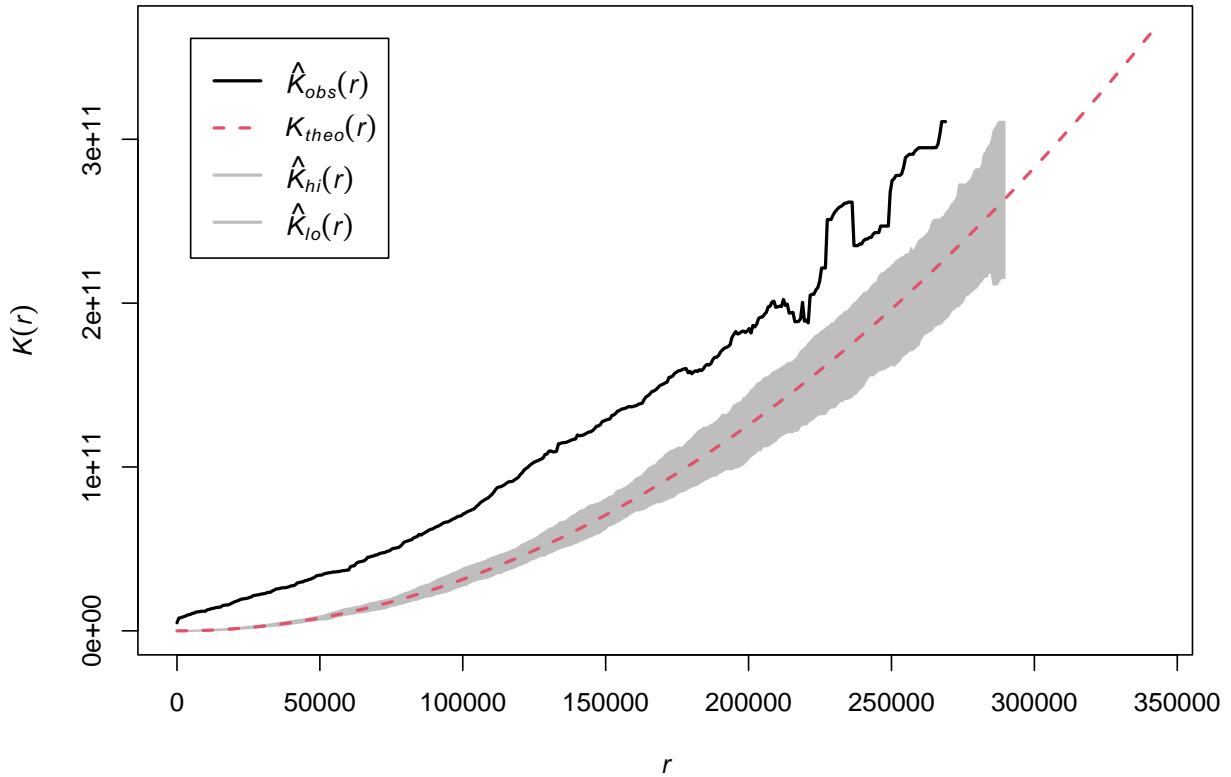
Adding confidence interval at a significance level of 0.05:

```
E_fox_homo <- envelope(parks_ppp,
    Kest,
    correction="border",
    rank = 1,
    nsim = 19, # aka alpha of 0.05
    fix.n = T)

## Generating 19 simulations of CSR with fixed number of points ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19.
##
## Done.

plot(E_fox_homo, lwd = 2)
```

## E\_fox\_homo



(I don't know why it only plotted these lines and not the other ones) We see that the effect appears significant. It is suspicious that the confidence bands increase a lot, (what's the explanation for that?)

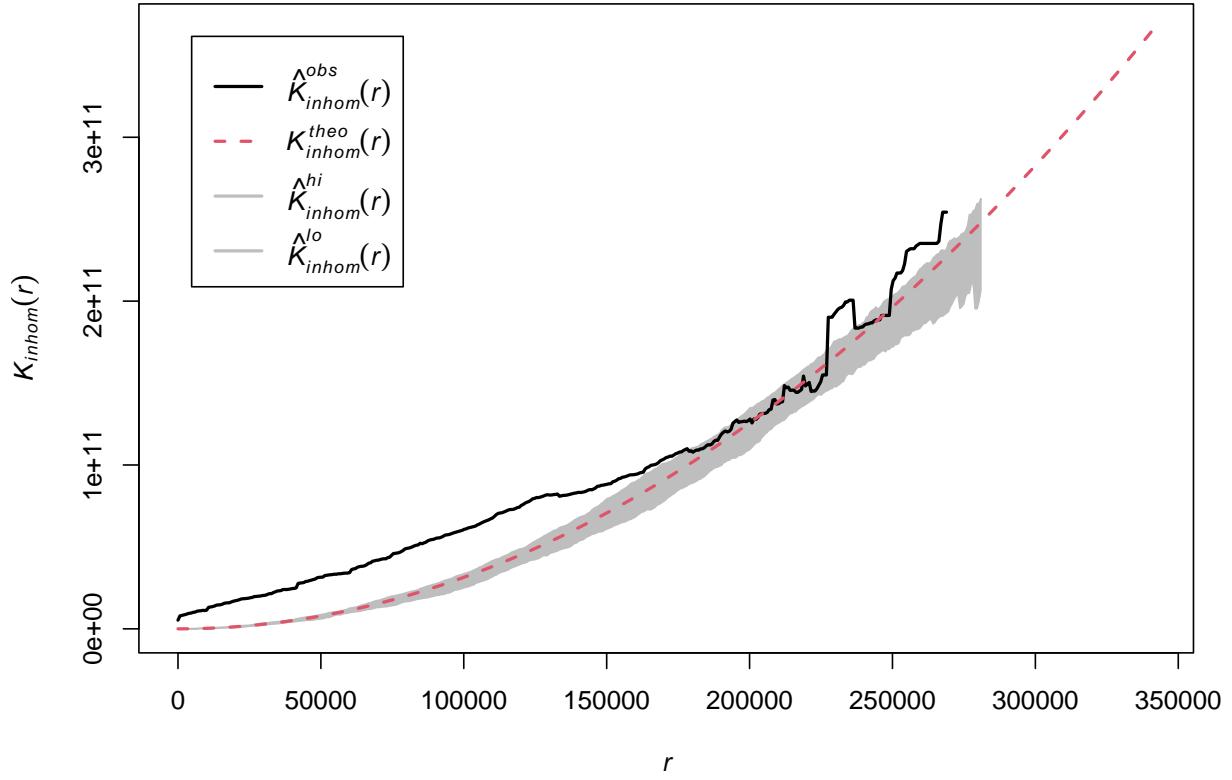
However, we know from first moment analysis that the intensity does not seem homogenous (right? Might need to double check). Trying inhomogenous:

```
E_fox <- envelope(parks_ppp,
  Kinhom,
  correction="border",
  rank = 1,
  nsim = 19, # aka alpha of 0.05
  fix.n = T)

## Generating 19 simulations of CSR with fixed number of points ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19.
##
## Done.

plot(E_fox, lwd = 2)
```

## E\_fox



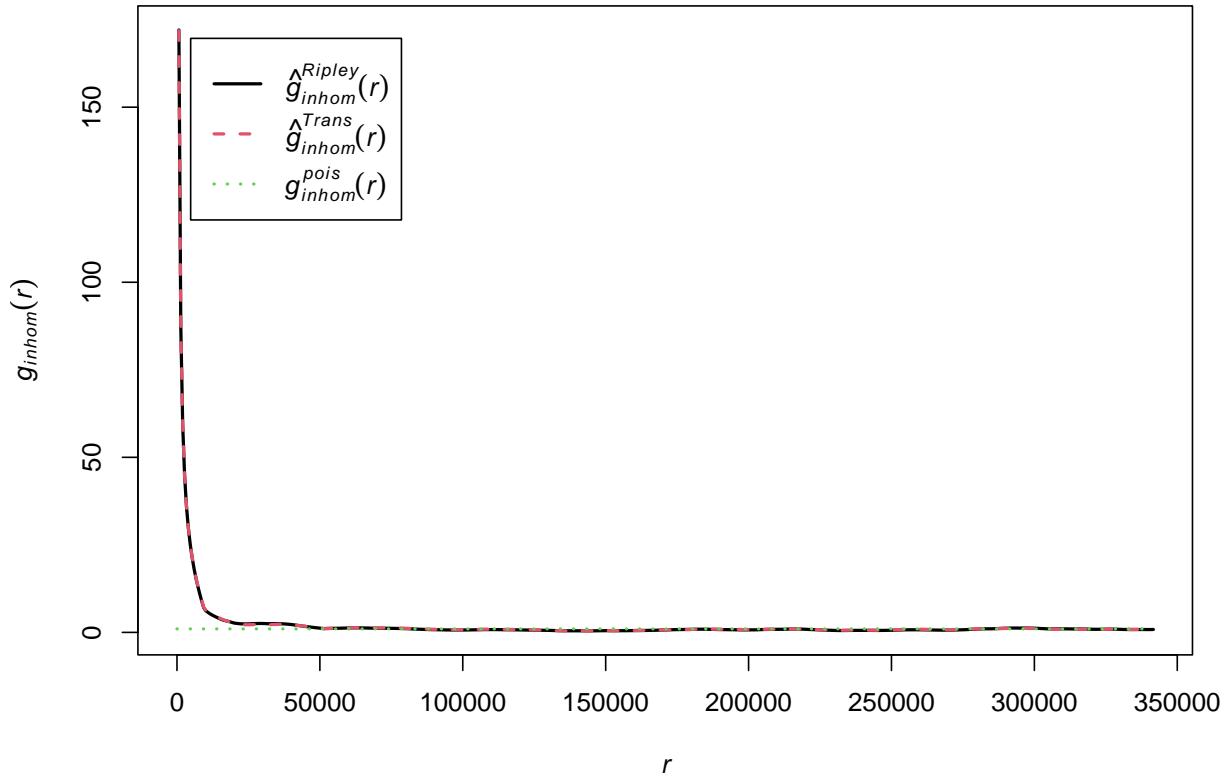
Using the Kinhom function ensures that we are not assuming the intensity is homogenous. It seems like from the smaller numbers, ie smaller distances between points, there is ‘evidence’ of clustering, whereas there are funny things going on as distances increase. The deviations are still meaningful in the ‘smaller’ distances, suggesting that the relationship between points may be due to effects between points rather than relationship with covariates.

### Pair correlation function

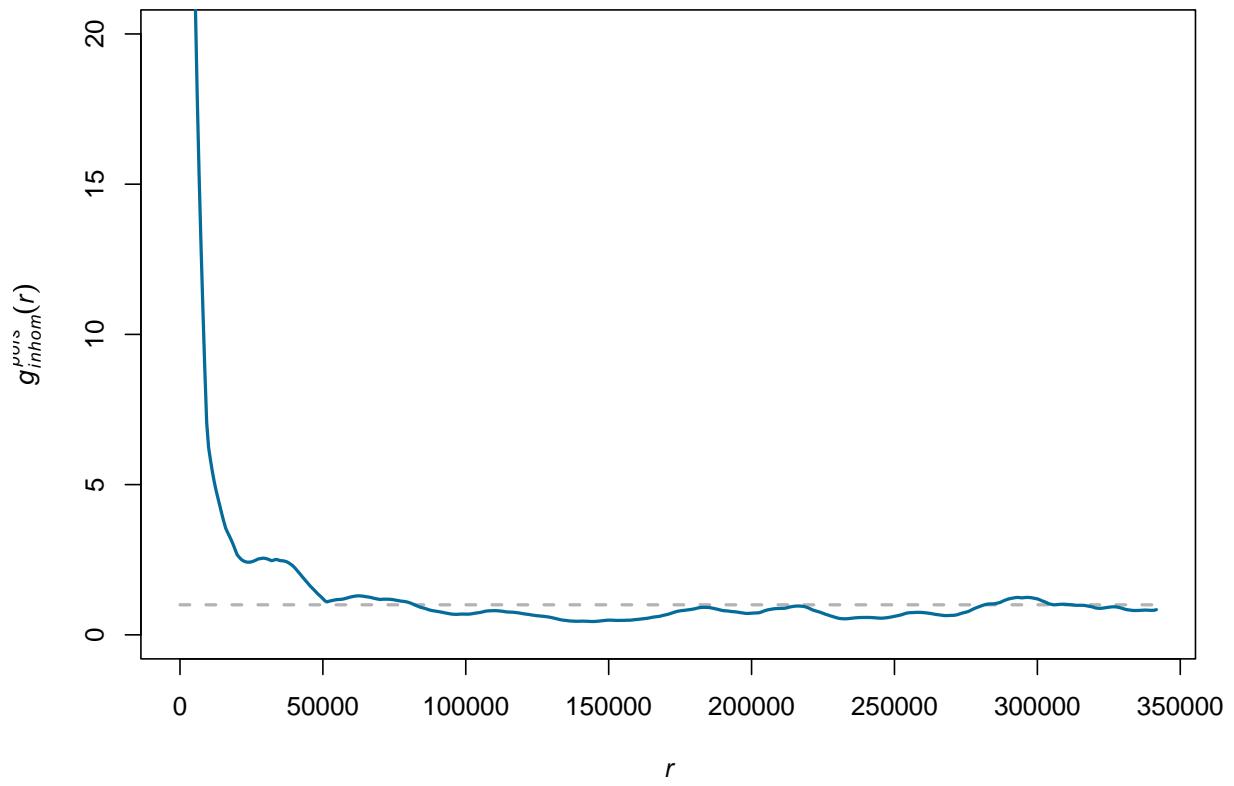
```
# Estimate the g function
pcf_fox <- pcfinhom(parks_ppp) # assumes inhomogeneity

# Default plot method
plot(pcf_fox, lwd = 2)
```

**pcf\_fox**



```
# visualise the results
plot(pcf_fox,
      theo ~ r,
      ylim = c(0,20),
      main = "",
      col = "grey70",
      lwd = 2,
      lty = "dashed")
plot(pcf_fox,
      iso ~ r,
      col = c("#046C9A"),
      lwd = 2,
      add = T)
```



We observe that there seem to be evidence for clustering at smaller than 50 000, but after that it rides the  $y = 1$  line slightly under.