589Project

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R Markdown

```
# read the CSV file into a data frame
mydata <- read.delim("vulpes.csv", sep ="\t")

# view the first few rows of the data frame
#head(mydata)
```

```
# Load the sp package
library(sp)
```

```
## Warning: package 'sp' was built under R version 4.2.3
```

```
library(rgdal)
```

```
## Warning: package 'rgdal' was built under R version 4.2.3

## Please note that rgdal will be retired during 2023,
## plan transition to sf/stars/terra functions using GDAL and PROJ
## at your earliest convenience.
## See https://r-spatial.org/r/2022/04/12/evolution.html and https://github.com/r-spatial/evolution
## rgdal: version: 1.6-5, (SVN revision 1199)
## Geospatial Data Abstraction Library extensions to R successfully loaded
## Loaded GDAL runtime: GDAL 3.5.2, released 2022/09/02
## Path to GDAL shared files: C:/Users/vijip/AppData/Local/R/win-library/4.2/rgdal/gdal
## GDAL binary built with GEOS: TRUE
## Loaded PROJ runtime: Rel. 8.2.1, January 1st, 2022, [PJ_VERSION: 821]
## Path to PROJ shared files: C:/Users/vijip/AppData/Local/R/win-library/4.2/rgdal/proj
## PROJ CDN enabled: FALSE
## Linking to sp version:1.6-0
## To mute warnings of possible GDAL/OSR exportToProj4() degradation,
## use options("rgdal_show_exportToProj4_warnings"="none") before loading sp or rgdal.
```

```
library(sf)
```

```
## Warning: package 'sf' was built under R version 4.2.3

## Linking to GEOS 3.9.3, GDAL 3.5.2, PROJ 8.2.1; sf_use_s2() is TRUE
```

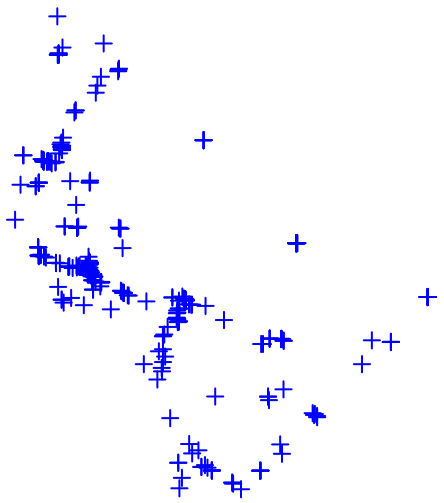
```
library(raster)
```

```
## Warning: package 'raster' was built under R version 4.2.3
```

```
# 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(mydata) <- CRS("+proj=longlat +datum=WGS84")
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 +

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

#data_transformed
data.sp_trans
```

```
## class       : SpatialPointsDataFrame
## features    : 517
## extent      : 237157.1, 1715294, 1001726, 2695828  (xmin, xmax, ymin, ymax)
## crs         : +proj=aea +lat_0=45 +lon_0=-126 +lat_1=50 +lat_2=58.5 +x_0=1000000 +y_0=0 +datum=NAD83
## variables   : 50
## names       :     gbifID,                              datasetKey,                    occurrenceID,  king
## min values  :  476806279, 0daed095-478a-4af6-abf5-18acb790fbb2,                                       , Anima
## max values  : 4062983640, f86a681d-7db8-483b-819a-248def18b70a, urn:catalog:UBCBBM:CTC:M002854, Anima
```

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




```
library(spatstat)
```

```
## Warning: package 'spatstat' was built under R version 4.2.3
```

```
## Loading required package: spatstat.data
```

```
## Warning: package 'spatstat.data' was built under R version 4.2.3
```

```
## Loading required package: spatstat.geom
```

```
## Warning: package 'spatstat.geom' was built under R version 4.2.3
```

```
## spatstat.geom 3.1-0
```

```
##
## Attaching package: 'spatstat.geom'
```

```
## The following objects are masked from 'package:raster':
##
##     area, rotate, shift
```

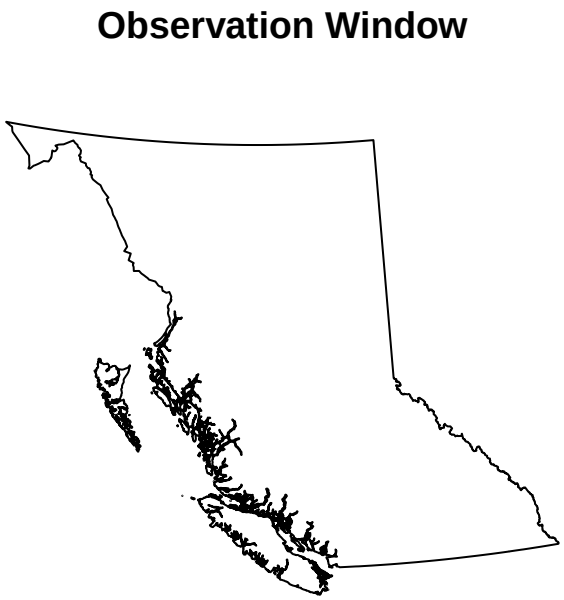
```
## Loading required package: spatstat.random
```

```
## Warning: package 'spatstat.random' was built under R version 4.2.3

## spatstat.random 3.1-4

## Loading required package: spatstat.explore

## Warning: package 'spatstat.explore' was built under R version 4.2.3

## Loading required package: nlme

##
## Attaching package: 'nlme'

## The following object is masked from 'package:raster':
##
##     getData

## spatstat.explore 3.1-0

## Loading required package: spatstat.model

## Warning: package 'spatstat.model' was built under R version 4.2.3

## Loading required package: rpart

## spatstat.model 3.2-1

## Loading required package: spatstat.linnet

## Warning: package 'spatstat.linnet' was built under R version 4.2.3

## spatstat.linnet 3.0-6

##
## spatstat 3.0-3
## For an introduction to spatstat, type 'beginner'
```

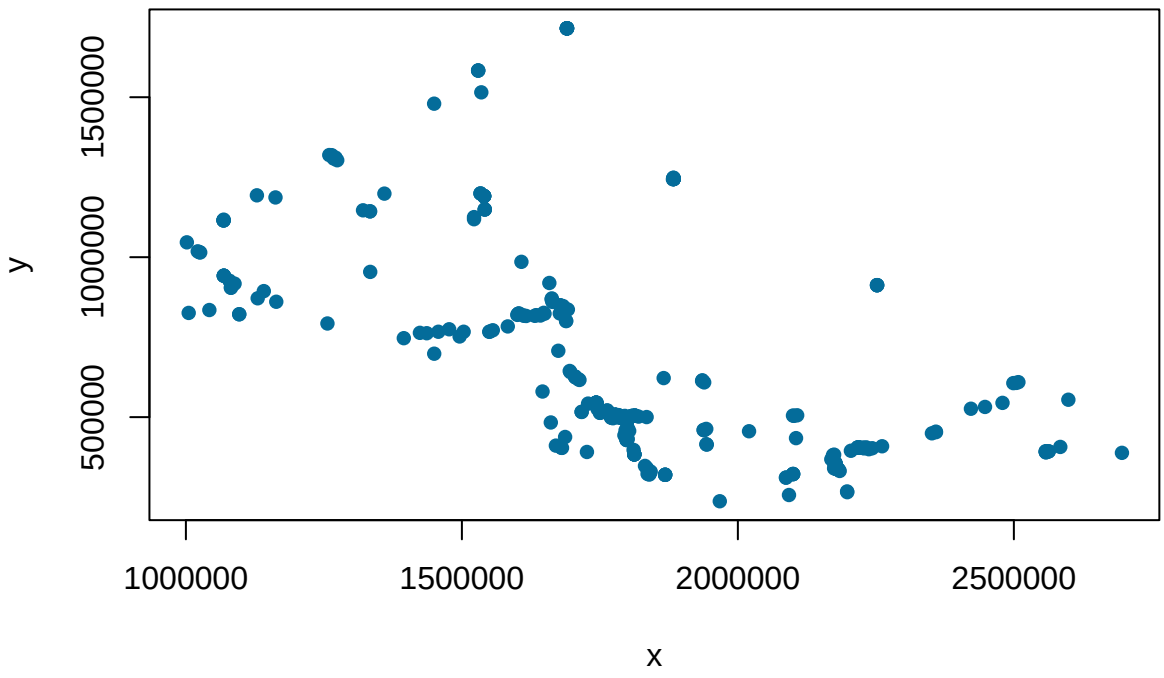
```
library(maptools)
```

```
## Warning: package 'maptools' was built under R version 4.2.3

## Checking rgeos availability: FALSE
## Please note that 'maptools' will be retired during 2023,
## plan transition at your earliest convenience;
## some functionality will be moved to 'sp'.
##      Note: when rgeos is not available, polygon geometry     computations in maptools depend on gpcli
##      which has a restricted licence. It is disabled by default;
##      to enable gpclib, type gpclibPermit()
```

```r
load("BC_Covariates.Rda")

#how to convert to OWIN object of this window so we can use the background?
#or do we have this window within our data itself?
#Convert the list to an owin object
#vulpes_win <- owin(poly = list(x=DATA$Parks$X,y=DATA$Parks$Y))

#Try to visualise the window using x and y
#plot(vulpes_win,
#     main = "Observation Window")

#As Window object is already present, use this to plot the observation window
plot(DATA$Window,
main = "Observation Window")
```




```r
data("bei")
# Analyze first moment and plot intensity -
x = data.sp_trans$decimalLatitude # X coordinates
y = data.sp_trans$decimalLongitude # Y coordinates

#Visualise the data
plot(y ~ x,
     pch = 16,
     col = "#046C9A",
     data = data.sp_trans)
```




```
#Convert to a ppp object, how to add Window? how to resolve 517 illegal points? what is it?

vulpes_win <- owin(poly = list(x=x,y=y))
vulpes_ppp <- ppp(x = data.sp_trans$decimalLatitude, # X coordinates
                  y = data.sp_trans$decimalLongitude, # Y coordinates
                  window = vulpes_win) # Observation window
```

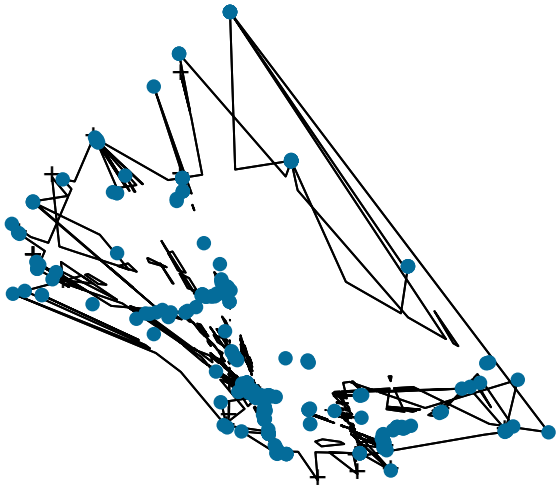
```
## Warning: point-in-polygon test had difficulty with 9 points (total score not 0
## or 1)
```

```
## Warning: 34 points were rejected as lying outside the specified window
```

```
## Warning: data contain duplicated points
```

```
#Visualise the dataset
plot(vulpes_ppp,
     pch = 16,
     cols = "#046C9A",
     main = "Vulpes point data")
```

```
## Warning in plot.ppp(vulpes_ppp, pch = 16, cols = "#046C9A", main = "Vulpes
## point data"): 34 illegal points also plotted
```



As we can see from the simple plot and the plot of ppp, the data of Vulpes Vulpes observation is not homogeneous. The intensity, if homogeneous

```
summary(vulpes_ppp)
```

```
## Planar point pattern:  483 points
## Average intensity 5.063089e-10 points per square unit
##
## *Pattern contains duplicated points*
##
## Coordinates are given to 2 decimal places
## i.e. rounded to the nearest multiple of 0.01 units
##
## Window: polygonal boundary
## 762 separate polygons (758 holes)
##                    vertices         area relative.area
## polygon 1               252  1.02818e+12      1.08e+00
## polygon 2 (hole)          7 -1.62215e+10     -1.70e-02
## polygon 3 (hole)         10 -2.80098e+08     -2.94e-04
## polygon 4 (hole)          3 -2.11176e+09     -2.21e-03
## polygon 5 (hole)          6 -2.85091e+07     -2.99e-05
## polygon 6 (hole)         14 -1.26778e+09     -1.33e-03
## polygon 7 (hole)         13 -1.86784e+10     -1.96e-02
## polygon 8 (hole)          3 -1.81151e+07     -1.90e-05
## polygon 9 (hole)          3 -9.83465e+07     -1.03e-04
## polygon 10 (hole)         3 -6.67501e+06     -7.00e-06
```

```
## polygon 11 (hole)        26 -4.76053e+09     -4.99e-03
## polygon 12 (hole)        18 -6.72024e+08     -7.04e-04
## polygon 13 (hole)         4 -2.22088e+07     -2.33e-05
## polygon 14 (hole)         4 -8.24727e+08     -8.65e-04
## polygon 15 (hole)         3 -1.23520e+08     -1.29e-04
## polygon 16 (hole)         9 -4.10565e+08     -4.30e-04
## polygon 17 (hole)         4 -2.94999e+06     -3.09e-06
## polygon 18 (hole)        11 -2.24509e+09     -2.35e-03
## polygon 19 (hole)         6 -2.95757e+07     -3.10e-05
## polygon 20 (hole)         4 -3.31588e+08     -3.48e-04
## polygon 21 (hole)        13 -2.88828e+08     -3.03e-04
## polygon 22 (hole)         3 -5.97559e-02     -6.26e-14
## polygon 23 (hole)         4 -1.34752e+08     -1.41e-04
## polygon 24 (hole)        18 -2.22226e+08     -2.33e-04
## polygon 25 (hole)         7 -6.45943e+07     -6.77e-05
## polygon 26 (hole)         4 -3.54440e+08     -3.72e-04
## polygon 27 (hole)        22 -4.46677e+08     -4.68e-04
## polygon 28 (hole)         4 -5.42877e+08     -5.69e-04
## polygon 29 (hole)         8 -3.81756e+07     -4.00e-05
## polygon 30 (hole)         4 -3.70320e+07     -3.88e-05
## polygon 31 (hole)         4 -5.43196e+06     -5.69e-06
## polygon 32 (hole)        15 -1.55809e+08     -1.63e-04
## polygon 33 (hole)        23 -8.25725e+07     -8.66e-05
## polygon 34 (hole)         4 -1.31100e+08     -1.37e-04
## polygon 35 (hole)         4 -1.92518e+08     -2.02e-04
## polygon 36 (hole)        13 -1.45045e+09     -1.52e-03
## polygon 37 (hole)         6 -4.43148e+07     -4.65e-05
## polygon 38 (hole)         3 -2.26919e+04     -2.38e-08
## polygon 39 (hole)         3 -5.29758e+06     -5.55e-06
## polygon 40 (hole)         4 -8.85204e+06     -9.28e-06
## polygon 41 (hole)         8 -1.34433e+07     -1.41e-05
## polygon 42 (hole)         3 -9.44875e+07     -9.90e-05
## polygon 43 (hole)         9 -1.32787e+07     -1.39e-05
## polygon 44 (hole)         3 -1.10962e+06     -1.16e-06
## polygon 45 (hole)         7 -3.23448e+06     -3.39e-06
## polygon 46 (hole)         7 -6.12812e+06     -6.42e-06
## polygon 47 (hole)         4 -7.18602e+06     -7.53e-06
## polygon 48 (hole)         8 -2.95392e+08     -3.10e-04
## polygon 49 (hole)        12 -7.73991e+08     -8.11e-04
## polygon 50 (hole)         8 -7.45869e+07     -7.82e-05
## polygon 51 (hole)         8 -2.15857e+08     -2.26e-04
## polygon 52 (hole)         8 -3.15837e+07     -3.31e-05
## polygon 53 (hole)         9 -4.16308e+08     -4.36e-04
## polygon 54 (hole)         3 -5.29220e+08     -5.55e-04
## polygon 55 (hole)         3 -8.01482e+03     -8.40e-09
## polygon 56 (hole)        32 -4.87738e+08     -5.11e-04
## polygon 57 (hole)         3 -4.48283e+05     -4.70e-07
## polygon 58 (hole)         8 -7.83339e+08     -8.21e-04
## polygon 59 (hole)         9 -1.57151e+08     -1.65e-04
## polygon 60 (hole)         3 -3.01826e+05     -3.16e-07
## polygon 61 (hole)         3 -2.43924e+05     -2.56e-07
## polygon 62 (hole)        12 -1.58079e+08     -1.66e-04
## polygon 63 (hole)        10 -6.97367e+07     -7.31e-05
## polygon 64 (hole)         9 -3.64894e+08     -3.83e-04
```

```
## polygon 65 (hole)        10 -1.67967e+07     -1.76e-05
## polygon 66 (hole)        18 -5.59089e+07     -5.86e-05
## polygon 67 (hole)        19 -1.52349e+08     -1.60e-04
## polygon 68 (hole)         5 -3.76146e+07     -3.94e-05
## polygon 69 (hole)         8 -2.26024e+08     -2.37e-04
## polygon 70 (hole)        31 -7.42287e+07     -7.78e-05
## polygon 71 (hole)         8 -9.92292e+06     -1.04e-05
## polygon 72 (hole)         7 -2.43497e+06     -2.55e-06
## polygon 73 (hole)         4 -9.31914e+06     -9.77e-06
## polygon 74 (hole)         4 -1.83124e+07     -1.92e-05
## polygon 75 (hole)         8 -1.92143e+07     -2.01e-05
## polygon 76 (hole)         8 -2.73865e+07     -2.87e-05
## polygon 77 (hole)         5 -7.58035e+07     -7.95e-05
## polygon 78 (hole)         9 -4.96918e+08     -5.21e-04
## polygon 79 (hole)         8 -1.12147e+08     -1.18e-04
## polygon 80 (hole)         5 -1.02546e+08     -1.07e-04
## polygon 81 (hole)         7 -3.93291e+08     -4.12e-04
## polygon 82 (hole)         8 -1.29006e+08     -1.35e-04
## polygon 83 (hole)         9 -3.21975e+07     -3.38e-05
## polygon 84 (hole)         4 -1.84303e+06     -1.93e-06
## polygon 85 (hole)         5 -1.12101e+08     -1.18e-04
## polygon 86 (hole)         4 -1.82209e+06     -1.91e-06
## polygon 87 (hole)        12 -1.37288e+06     -1.44e-06
## polygon 88 (hole)        23 -1.48369e+08     -1.56e-04
## polygon 89 (hole)         3 -2.98152e+03     -3.13e-09
## polygon 90 (hole)        16 -2.93060e+07     -3.07e-05
## polygon 91 (hole)         4 -5.45038e+06     -5.71e-06
## polygon 92 (hole)         4 -1.07486e+07     -1.13e-05
## polygon 93 (hole)         8 -1.46832e+07     -1.54e-05
## polygon 94 (hole)         6 -7.98138e+05     -8.37e-07
## polygon 95 (hole)         4 -9.79760e+05     -1.03e-06
## polygon 96 (hole)         4 -3.26917e+06     -3.43e-06
## polygon 97 (hole)         9 -4.21880e+05     -4.42e-07
## polygon 98 (hole)         5 -7.41185e+07     -7.77e-05
## polygon 99 (hole)         7 -6.95054e+06     -7.29e-06
## polygon 100 (hole)        4 -7.58962e+06     -7.96e-06
## polygon 101 (hole)        8 -4.00120e+06     -4.19e-06
## polygon 102 (hole)        7 -8.58243e+05     -9.00e-07
## polygon 103 (hole)        8 -2.69901e+07     -2.83e-05
## polygon 104 (hole)        6 -1.93330e+07     -2.03e-05
## polygon 105 (hole)       11 -2.48701e+07     -2.61e-05
## polygon 106 (hole)       21 -5.56757e+06     -5.84e-06
## polygon 107 (hole)        4 -1.06255e+06     -1.11e-06
## polygon 108 (hole)       12 -8.88247e+06     -9.31e-06
## polygon 109 (hole)       11 -1.27212e+08     -1.33e-04
## polygon 110 (hole)        4 -1.17765e+06     -1.23e-06
## polygon 111 (hole)        4 -4.38868e+06     -4.60e-06
## polygon 112 (hole)        4 -6.30637e+06     -6.61e-06
## polygon 113 (hole)       11 -4.72001e+06     -4.95e-06
## polygon 114 (hole)       18 -1.19851e+07     -1.26e-05
## polygon 115 (hole)        4 -2.55991e+05     -2.68e-07
## polygon 116 (hole)        3 -2.62732e+06     -2.75e-06
## polygon 117 (hole)       21 -1.85711e+07     -1.95e-05
## polygon 118 (hole)        3 -1.27691e+02     -1.34e-10
```

```
## polygon 119 (hole)       12 -2.77904e+07     -2.91e-05
## polygon 120 (hole)        4 -3.45871e+06     -3.63e-06
## polygon 121 (hole)       12 -7.28070e+07     -7.63e-05
## polygon 122 (hole)        8 -8.22770e+07     -8.62e-05
## polygon 123 (hole)        7 -2.98913e+06     -3.13e-06
## polygon 124 (hole)       24 -8.31463e+09     -8.72e-03
## polygon 125 (hole)        4 -4.01092e+05     -4.20e-07
## polygon 126 (hole)        9 -1.88463e+07     -1.98e-05
## polygon 127 (hole)        3 -1.67789e+05     -1.76e-07
## polygon 128 (hole)        7 -3.60092e+06     -3.77e-06
## polygon 129 (hole)        4 -7.28358e+07     -7.64e-05
## polygon 130 (hole)        7 -3.23621e+06     -3.39e-06
## polygon 131 (hole)        8 -6.75838e+05     -7.08e-07
## polygon 132 (hole)        8 -2.86915e+06     -3.01e-06
## polygon 133 (hole)       17 -7.87938e+06     -8.26e-06
## polygon 134 (hole)        4 -5.63748e+05     -5.91e-07
## polygon 135 (hole)       12 -2.72809e+07     -2.86e-05
## polygon 136 (hole)       15 -1.58082e+07     -1.66e-05
## polygon 137 (hole)        9 -3.38251e+07     -3.55e-05
## polygon 138 (hole)        4 -1.27253e+07     -1.33e-05
## polygon 139 (hole)        8 -3.05605e+06     -3.20e-06
## polygon 140 (hole)        4 -2.00212e+07     -2.10e-05
## polygon 141 (hole)        9 -1.81861e+08     -1.91e-04
## polygon 142 (hole)       15 -1.52695e+07     -1.60e-05
## polygon 143 (hole)        4 -3.01170e+08     -3.16e-04
## polygon 144               8  8.18370e+09      8.58e-03
## polygon 145 (hole)        8 -5.12951e+06     -5.38e-06
## polygon 146 (hole)        4 -1.21352e+06     -1.27e-06
## polygon 147 (hole)        3 -1.44015e+06     -1.51e-06
## polygon 148 (hole)        4 -8.70619e+06     -9.13e-06
## polygon 149 (hole)       21 -4.27353e+07     -4.48e-05
## polygon 150 (hole)        4 -1.10737e+07     -1.16e-05
## polygon 151 (hole)        7 -3.42375e+08     -3.59e-04
## polygon 152 (hole)       12 -9.83831e+06     -1.03e-05
## polygon 153 (hole)        4 -1.96276e+07     -2.06e-05
## polygon 154 (hole)        9 -1.08279e+09     -1.14e-03
## polygon 155 (hole)       19 -7.24615e+05     -7.60e-07
## polygon 156 (hole)        6 -7.86689e+02     -8.25e-10
## polygon 157 (hole)       13 -3.65317e+07     -3.83e-05
## polygon 158 (hole)       23 -6.84754e+06     -7.18e-06
## polygon 159 (hole)        6 -1.33618e+06     -1.40e-06
## polygon 160 (hole)       14 -7.29143e+05     -7.64e-07
## polygon 161 (hole)       10 -4.11355e+07     -4.31e-05
## polygon 162 (hole)        4 -3.43317e+04     -3.60e-08
## polygon 163 (hole)        8 -1.31790e+07     -1.38e-05
## polygon 164 (hole)        3 -1.95819e+03     -2.05e-09
## polygon 165 (hole)        4 -1.79297e+07     -1.88e-05
## polygon 166 (hole)       15 -1.87043e+07     -1.96e-05
## polygon 167 (hole)       12 -8.31247e+06     -8.71e-06
## polygon 168 (hole)       17 -4.85325e+07     -5.09e-05
## polygon 169 (hole)       15 -1.76171e+07     -1.85e-05
## polygon 170 (hole)        3 -4.56260e+06     -4.78e-06
## polygon 171 (hole)        4 -1.57880e+07     -1.65e-05
## polygon 172 (hole)        4 -4.02977e+05     -4.22e-07
```

```
## polygon 173 (hole)        7 -4.45020e+08     -4.66e-04
## polygon 174 (hole)       10 -2.74869e+07     -2.88e-05
## polygon 175 (hole)        4 -4.32882e+08     -4.54e-04
## polygon 176 (hole)        4 -1.02400e+05     -1.07e-07
## polygon 177 (hole)        4 -3.07914e+05     -3.23e-07
## polygon 178 (hole)        5 -2.77137e+07     -2.91e-05
## polygon 179 (hole)        4 -3.59253e+06     -3.77e-06
## polygon 180 (hole)        4 -8.81890e+06     -9.24e-06
## polygon 181 (hole)        9 -3.08691e+08     -3.24e-04
## polygon 182 (hole)        4 -2.62813e+06     -2.75e-06
## polygon 183 (hole)        8 -4.97172e+09     -5.21e-03
## polygon 184 (hole)       10 -3.66974e+04     -3.85e-08
## polygon 185 (hole)        6 -1.97717e+06     -2.07e-06
## polygon 186 (hole)       10 -6.14049e+06     -6.44e-06
## polygon 187 (hole)       19 -1.70395e+09     -1.79e-03
## polygon 188 (hole)       10 -5.78767e+06     -6.07e-06
## polygon 189 (hole)        3 -1.30113e+02     -1.36e-10
## polygon 190 (hole)        7 -4.78916e+05     -5.02e-07
## polygon 191 (hole)        9 -1.29161e+05     -1.35e-07
## polygon 192 (hole)       14 -1.37616e+06     -1.44e-06
## polygon 193 (hole)        4 -3.77795e+05     -3.96e-07
## polygon 194 (hole)        7 -2.38807e+06     -2.50e-06
## polygon 195 (hole)       17 -3.89855e+05     -4.09e-07
## polygon 196 (hole)        4 -2.06699e+07     -2.17e-05
## polygon 197 (hole)        7 -2.00307e+05     -2.10e-07
## polygon 198 (hole)       18 -2.38823e+05     -2.50e-07
## polygon 199 (hole)       15 -7.69871e+05     -8.07e-07
## polygon 200 (hole)        5 -5.63126e+04     -5.90e-08
## polygon 201 (hole)       15 -7.70885e+06     -8.08e-06
## polygon 202 (hole)       11 -5.54030e+05     -5.81e-07
## polygon 203 (hole)        4 -5.65138e+04     -5.92e-08
## polygon 204 (hole)        3 -3.15480e+03     -3.31e-09
## polygon 205 (hole)       16 -1.30705e+08     -1.37e-04
## polygon 206 (hole)       12 -3.78331e+06     -3.97e-06
## polygon 207 (hole)       14 -5.49108e+05     -5.76e-07
## polygon 208 (hole)        9 -1.29079e+05     -1.35e-07
## polygon 209 (hole)        3 -1.51316e+06     -1.59e-06
## polygon 210 (hole)       13 -3.24259e+05     -3.40e-07
## polygon 211 (hole)        4 -3.64484e+07     -3.82e-05
## polygon 212 (hole)        4 -1.75118e+05     -1.84e-07
## polygon 213 (hole)        8 -4.16818e+04     -4.37e-08
## polygon 214 (hole)       10 -6.85279e+05     -7.18e-07
## polygon 215 (hole)        9 -7.79475e+06     -8.17e-06
## polygon 216 (hole)       10 -5.29025e+06     -5.55e-06
## polygon 217 (hole)        5 -2.78104e+07     -2.92e-05
## polygon 218 (hole)        5 -1.55511e+06     -1.63e-06
## polygon 219 (hole)       31 -2.23801e+06     -2.35e-06
## polygon 220 (hole)        8 -2.56296e+03     -2.69e-09
## polygon 221 (hole)        9 -7.07693e+04     -7.42e-08
## polygon 222 (hole)        4 -6.13710e+05     -6.43e-07
## polygon 223 (hole)        8 -3.58065e+05     -3.75e-07
## polygon 224 (hole)        8 -5.18492e+07     -5.44e-05
## polygon 225 (hole)        4 -7.15456e+03     -7.50e-09
## polygon 226 (hole)       11 -4.01527e+05     -4.21e-07
```

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## polygon 227 (hole)        4 -4.40968e+04     -4.62e-08
## polygon 228 (hole)        8 -4.66938e+05     -4.89e-07
## polygon 229 (hole)       20 -5.40685e+05     -5.67e-07
## polygon 230 (hole)       16 -6.57643e+05     -6.89e-07
## polygon 231 (hole)       16 -8.22500e+05     -8.62e-07
## polygon 232 (hole)       11 -4.28672e+05     -4.49e-07
## polygon 233 (hole)        5 -4.46248e+03     -4.68e-09
## polygon 234 (hole)       18 -1.25354e+08     -1.31e-04
## polygon 235 (hole)        4 -1.16144e+03     -1.22e-09
## polygon 236 (hole)       11 -7.88965e+05     -8.27e-07
## polygon 237 (hole)        4 -2.45306e+04     -2.57e-08
## polygon 238 (hole)        3 -5.40225e+04     -5.66e-08
## polygon 239 (hole)        5 -2.70851e+05     -2.84e-07
## polygon 240 (hole)        7 -1.50757e+05     -1.58e-07
## polygon 241 (hole)        9 -4.06331e+05     -4.26e-07
## polygon 242 (hole)        4 -1.20112e+04     -1.26e-08
## polygon 243 (hole)        5 -6.96149e+05     -7.30e-07
## polygon 244 (hole)       10 -1.61213e+06     -1.69e-06
## polygon 245 (hole)       11 -4.28231e+05     -4.49e-07
## polygon 246 (hole)        4 -6.13527e+07     -6.43e-05
## polygon 247 (hole)        8 -9.41166e+05     -9.87e-07
## polygon 248 (hole)        4 -8.31048e+03     -8.71e-09
## polygon 249 (hole)        4 -4.82338e+05     -5.06e-07
## polygon 250 (hole)        5 -6.68623e+04     -7.01e-08
## polygon 251 (hole)       14 -5.53971e+05     -5.81e-07
## polygon 252 (hole)        4 -1.14193e+05     -1.20e-07
## polygon 253 (hole)        6 -5.08948e+05     -5.34e-07
## polygon 254 (hole)        3 -1.83429e+05     -1.92e-07
## polygon 255 (hole)       32 -4.32459e+05     -4.53e-07
## polygon 256 (hole)        5 -1.87909e+05     -1.97e-07
## polygon 257 (hole)        5 -4.46892e+05     -4.68e-07
## polygon 258 (hole)        4 -1.19273e+05     -1.25e-07
## polygon 259 (hole)       12 -1.61504e+05     -1.69e-07
## polygon 260 (hole)        9 -6.39125e+05     -6.70e-07
## polygon 261 (hole)        4 -2.02461e+04     -2.12e-08
## polygon 262 (hole)       27 -2.18887e+06     -2.29e-06
## polygon 263 (hole)       14 -9.03560e+05     -9.47e-07
## polygon 264 (hole)        4 -5.85031e+03     -6.13e-09
## polygon 265 (hole)        8 -6.83982e+03     -7.17e-09
## polygon 266 (hole)        3 -4.00654e+01     -4.20e-11
## polygon 267 (hole)        3 -4.00195e+05     -4.20e-07
## polygon 268 (hole)        4 -4.97338e+04     -5.21e-08
## polygon 269 (hole)        8 -1.13758e+04     -1.19e-08
## polygon 270 (hole)        3 -2.67320e+04     -2.80e-08
## polygon 271 (hole)        9 -1.12691e+05     -1.18e-07
## polygon 272 (hole)        4 -8.85906e+04     -9.29e-08
## polygon 273 (hole)       14 -3.36374e+05     -3.53e-07
## polygon 274 (hole)        6 -1.86074e+05     -1.95e-07
## polygon 275 (hole)        4 -1.51454e+05     -1.59e-07
## polygon 276 (hole)       10 -7.96882e+04     -8.35e-08
## polygon 277 (hole)        9 -1.18221e+05     -1.24e-07
## polygon 278 (hole)       19 -2.64491e+05     -2.77e-07
## polygon 279 (hole)        5 -6.19924e+04     -6.50e-08
## polygon 280 (hole)        8 -3.62414e+04     -3.80e-08
```

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## polygon 281 (hole)       11 -3.86788e+05     -4.05e-07
## polygon 282 (hole)        5 -1.57457e+05     -1.65e-07
## polygon 283 (hole)        3 -1.42574e+03     -1.49e-09
## polygon 284 (hole)        3 -1.54856e+03     -1.62e-09
## polygon 285 (hole)        3 -1.92616e+03     -2.02e-09
## polygon 286 (hole)        3 -6.12658e+04     -6.42e-08
## polygon 287 (hole)        3 -1.49395e+02     -1.57e-10
## polygon 288 (hole)       18 -5.73542e+05     -6.01e-07
## polygon 289 (hole)        4 -1.47079e+04     -1.54e-08
## polygon 290 (hole)        4 -2.09197e+05     -2.19e-07
## polygon 291 (hole)       15 -9.88445e+04     -1.04e-07
## polygon 292 (hole)        5 -2.22724e+04     -2.33e-08
## polygon 293 (hole)       43 -4.42978e+05     -4.64e-07
## polygon 294 (hole)        9 -8.06314e+04     -8.45e-08
## polygon 295 (hole)        5 -1.26417e+04     -1.33e-08
## polygon 296 (hole)       12 -3.60858e+05     -3.78e-07
## polygon 297 (hole)        9 -4.92156e+05     -5.16e-07
## polygon 298 (hole)        4 -3.46396e+04     -3.63e-08
## polygon 299 (hole)        4 -1.39791e+04     -1.47e-08
## polygon 300 (hole)        4 -1.26219e+05     -1.32e-07
## polygon 301 (hole)       25 -1.65585e+05     -1.74e-07
## polygon 302 (hole)        9 -2.43446e+04     -2.55e-08
## polygon 303 (hole)       23 -6.10605e+04     -6.40e-08
## polygon 304 (hole)        8 -2.78486e+04     -2.92e-08
## polygon 305 (hole)        3 -3.45167e+03     -3.62e-09
## polygon 306 (hole)        6 -1.07031e+03     -1.12e-09
## polygon 307 (hole)       25 -1.82996e+05     -1.92e-07
## polygon 308 (hole)       15 -1.25114e+05     -1.31e-07
## polygon 309 (hole)        3 -1.90185e+03     -1.99e-09
## polygon 310 (hole)        9 -9.60090e+05     -1.01e-06
## polygon 311 (hole)        7 -9.03190e+04     -9.47e-08
## polygon 312 (hole)        7 -1.29208e+04     -1.35e-08
## polygon 313 (hole)       16 -7.02007e+04     -7.36e-08
## polygon 314 (hole)        4 -8.34061e+04     -8.74e-08
## polygon 315 (hole)        6 -4.23736e+04     -4.44e-08
## polygon 316 (hole)        8 -1.49319e+04     -1.57e-08
## polygon 317 (hole)        6 -2.64480e+04     -2.77e-08
## polygon 318 (hole)        9 -2.58667e+05     -2.71e-07
## polygon 319 (hole)        7 -1.02292e+04     -1.07e-08
## polygon 320 (hole)       19 -3.66942e+04     -3.85e-08
## polygon 321 (hole)        8 -3.46137e+04     -3.63e-08
## polygon 322 (hole)       16 -5.89619e+04     -6.18e-08
## polygon 323 (hole)       16 -4.30266e+04     -4.51e-08
## polygon 324 (hole)       18 -1.73775e+05     -1.82e-07
## polygon 325 (hole)       25 -2.90603e+05     -3.05e-07
## polygon 326 (hole)        8 -6.42666e+03     -6.74e-09
## polygon 327 (hole)        7 -3.04060e+03     -3.19e-09
## polygon 328 (hole)       22 -7.43414e+04     -7.79e-08
## polygon 329 (hole)       12 -8.98337e+03     -9.42e-09
## polygon 330 (hole)        7 -1.35655e+04     -1.42e-08
## polygon 331 (hole)        8 -4.61563e+04     -4.84e-08
## polygon 332 (hole)       11 -3.30182e+04     -3.46e-08
## polygon 333 (hole)        9 -7.69828e+04     -8.07e-08
## polygon 334 (hole)        8 -3.97952e+03     -4.17e-09
```

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## polygon 335 (hole)        3 -3.68663e+02     -3.86e-10
## polygon 336 (hole)       13 -1.14905e+04     -1.20e-08
## polygon 337 (hole)        8 -5.57647e+04     -5.85e-08
## polygon 338 (hole)        3 -2.06494e+02     -2.16e-10
## polygon 339 (hole)       17 -2.28131e+03     -2.39e-09
## polygon 340 (hole)       26 -3.07730e+05     -3.23e-07
## polygon 341 (hole)        7 -5.56473e+02     -5.83e-10
## polygon 342 (hole)        6 -6.39400e+02     -6.70e-10
## polygon 343 (hole)        5 -2.57456e+05     -2.70e-07
## polygon 344 (hole)        3 -1.28911e+02     -1.35e-10
## polygon 345 (hole)        3 -1.25072e+02     -1.31e-10
## polygon 346 (hole)        9 -4.81042e+03     -5.04e-09
## polygon 347 (hole)        3 -4.04916e+03     -4.24e-09
## polygon 348 (hole)        4 -3.56605e+04     -3.74e-08
## polygon 349 (hole)        4 -3.18876e+02     -3.34e-10
## polygon 350 (hole)        4 -1.28402e+05     -1.35e-07
## polygon 351 (hole)        3 -4.79286e+04     -5.02e-08
## polygon 352 (hole)        4 -7.09295e+03     -7.44e-09
## polygon 353 (hole)       12 -3.81308e+05     -4.00e-07
## polygon 354 (hole)        4 -1.71588e+05     -1.80e-07
## polygon 355 (hole)        4 -4.52478e+04     -4.74e-08
## polygon 356 (hole)       14 -2.15067e+07     -2.25e-05
## polygon 357 (hole)       10 -1.80210e+05     -1.89e-07
## polygon 358 (hole)        3 -1.30896e+02     -1.37e-10
## polygon 359 (hole)        4 -3.06030e+03     -3.21e-09
## polygon 360 (hole)        4 -1.96927e+03     -2.06e-09
## polygon 361 (hole)        5 -7.07727e+04     -7.42e-08
## polygon 362 (hole)        8 -2.54307e+02     -2.67e-10
## polygon 363 (hole)        7 -2.41592e+04     -2.53e-08
## polygon 364 (hole)       19 -4.05261e+03     -4.25e-09
## polygon 365 (hole)        3 -1.41576e+05     -1.48e-07
## polygon 366 (hole)       14 -4.57867e+03     -4.80e-09
## polygon 367 (hole)        6 -1.82060e+03     -1.91e-09
## polygon 368 (hole)        6 -1.18156e+03     -1.24e-09
## polygon 369 (hole)       13 -3.31412e+03     -3.47e-09
## polygon 370 (hole)       17 -1.21401e+04     -1.27e-08
## polygon 371 (hole)       19 -3.02320e+03     -3.17e-09
## polygon 372 (hole)        5 -1.35554e+03     -1.42e-09
## polygon 373 (hole)        9 -2.97502e+02     -3.12e-10
## polygon 374 (hole)        6 -1.38606e+02     -1.45e-10
## polygon 375 (hole)       13 -6.06848e+04     -6.36e-08
## polygon 376 (hole)        7 -1.05381e+04     -1.10e-08
## polygon 377 (hole)       14 -1.29329e+03     -1.36e-09
## polygon 378 (hole)        4 -5.74325e+01     -6.02e-11
## polygon 379 (hole)        7 -1.14571e+03     -1.20e-09
## polygon 380 (hole)        5 -2.13674e+05     -2.24e-07
## polygon 381 (hole)        3 -2.57634e+00     -2.70e-12
## polygon 382 (hole)        4 -1.64178e+01     -1.72e-11
## polygon 383 (hole)       23 -5.62935e+03     -5.90e-09
## polygon 384 (hole)        3 -3.48291e+01     -3.65e-11
## polygon 385 (hole)        7 -2.16020e+02     -2.26e-10
## polygon 386 (hole)        9 -6.56339e+04     -6.88e-08
## polygon 387 (hole)        4 -1.03800e+04     -1.09e-08
## polygon 388 (hole)        4 -3.24304e+04     -3.40e-08
```

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## polygon 389 (hole)        4 -2.25988e+05     -2.37e-07
## polygon 390 (hole)        8 -3.57108e+05     -3.74e-07
## polygon 391 (hole)        7 -6.29461e+04     -6.60e-08
## polygon 392 (hole)        3 -2.34560e-03     -2.46e-15
## polygon 393 (hole)        7 -1.47718e+03     -1.55e-09
## polygon 394 (hole)        4 -3.49760e+03     -3.67e-09
## polygon 395 (hole)       16 -8.21432e+03     -8.61e-09
## polygon 396 (hole)        5 -6.40542e+06     -6.71e-06
## polygon 397 (hole)       19 -6.31053e+03     -6.62e-09
## polygon 398 (hole)        3 -2.00106e-02     -2.10e-14
## polygon 399 (hole)        7 -7.41971e+03     -7.78e-09
## polygon 400 (hole)       12 -3.61395e+03     -3.79e-09
## polygon 401 (hole)       18 -1.42771e+03     -1.50e-09
## polygon 402 (hole)       13 -3.28953e+03     -3.45e-09
## polygon 403 (hole)       18 -6.03498e+03     -6.33e-09
## polygon 404 (hole)        6 -2.16080e+03     -2.27e-09
## polygon 405 (hole)        8 -1.37893e+04     -1.45e-08
## polygon 406 (hole)       13 -3.05355e+03     -3.20e-09
## polygon 407 (hole)        4 -1.22592e+02     -1.29e-10
## polygon 408 (hole)        6 -4.17476e+02     -4.38e-10
## polygon 409 (hole)        5 -1.07644e+04     -1.13e-08
## polygon 410 (hole)        5 -6.23562e+03     -6.54e-09
## polygon 411 (hole)       12 -3.07070e+04     -3.22e-08
## polygon 412 (hole)        4 -7.92229e+02     -8.30e-10
## polygon 413 (hole)        8 -3.41080e+03     -3.58e-09
## polygon 414 (hole)        4 -3.11765e+01     -3.27e-11
## polygon 415 (hole)        3 -5.87905e+01     -6.16e-11
## polygon 416 (hole)       19 -1.39627e+04     -1.46e-08
## polygon 417 (hole)       14 -8.70912e+03     -9.13e-09
## polygon 418 (hole)       13 -4.80021e+03     -5.03e-09
## polygon 419 (hole)        6 -4.05663e+02     -4.25e-10
## polygon 420 (hole)        9 -1.04363e+05     -1.09e-07
## polygon 421 (hole)        8 -3.35662e+03     -3.52e-09
## polygon 422 (hole)       10 -1.94735e+03     -2.04e-09
## polygon 423 (hole)        3 -3.02273e+02     -3.17e-10
## polygon 424 (hole)        4 -7.16079e+02     -7.51e-10
## polygon 425 (hole)       23 -9.88984e+07     -1.04e-04
## polygon 426 (hole)       11 -6.53874e+02     -6.85e-10
## polygon 427 (hole)       12 -2.00273e+03     -2.10e-09
## polygon 428 (hole)        4 -2.01878e+04     -2.12e-08
## polygon 429 (hole)        4 -2.64941e+04     -2.78e-08
## polygon 430 (hole)       35 -1.48796e+05     -1.56e-07
## polygon 431 (hole)        9 -4.53448e+03     -4.75e-09
## polygon 432 (hole)       11 -2.35052e+04     -2.46e-08
## polygon 433 (hole)       12 -4.00278e+04     -4.20e-08
## polygon 434 (hole)       12 -3.74699e+05     -3.93e-07
## polygon 435 (hole)       11 -1.56117e+06     -1.64e-06
## polygon 436 (hole)        4 -7.49622e+03     -7.86e-09
## polygon 437 (hole)        4 -1.00464e+04     -1.05e-08
## polygon 438 (hole)       12 -6.85983e+03     -7.19e-09
## polygon 439 (hole)       12 -1.49380e+04     -1.57e-08
## polygon 440 (hole)        9 -3.69505e+04     -3.87e-08
## polygon 441 (hole)       14 -3.91290e+04     -4.10e-08
## polygon 442 (hole)        4 -4.73481e+03     -4.96e-09
```

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## polygon 443 (hole)        4 -1.48411e+05     -1.56e-07
## polygon 444 (hole)       11 -1.36063e+03     -1.43e-09
## polygon 445 (hole)        7 -1.11389e+03     -1.17e-09
## polygon 446 (hole)        5 -8.44778e+03     -8.86e-09
## polygon 447 (hole)        3 -2.50131e+02     -2.62e-10
## polygon 448 (hole)        5 -4.69678e+03     -4.92e-09
## polygon 449 (hole)        4 -6.84941e+02     -7.18e-10
## polygon 450 (hole)        8 -5.51761e+03     -5.78e-09
## polygon 451 (hole)       20 -7.76265e+03     -8.14e-09
## polygon 452 (hole)        4 -6.42709e+02     -6.74e-10
## polygon 453 (hole)       10 -3.53829e+05     -3.71e-07
## polygon 454 (hole)        4 -9.03087e+03     -9.47e-09
## polygon 455 (hole)       37 -1.81389e+05     -1.90e-07
## polygon 456 (hole)        6 -2.37054e+04     -2.48e-08
## polygon 457 (hole)        4 -5.57164e+03     -5.84e-09
## polygon 458 (hole)        4 -2.64717e+01     -2.77e-11
## polygon 459 (hole)        4 -1.91596e+02     -2.01e-10
## polygon 460 (hole)        3 -1.21372e-01     -1.27e-13
## polygon 461 (hole)       17 -2.59904e+04     -2.72e-08
## polygon 462 (hole)       18 -8.27481e+03     -8.67e-09
## polygon 463 (hole)        4 -2.79319e+03     -2.93e-09
## polygon 464 (hole)        4 -6.08636e+04     -6.38e-08
## polygon 465 (hole)        7 -1.66251e+03     -1.74e-09
## polygon 466 (hole)        4 -1.18037e+04     -1.24e-08
## polygon 467 (hole)        3 -1.19711e+01     -1.25e-11
## polygon 468 (hole)       11 -2.27689e+08     -2.39e-04
## polygon 469 (hole)        4 -1.80603e+03     -1.89e-09
## polygon 470 (hole)       14 -1.62396e+06     -1.70e-06
## polygon 471 (hole)        4 -9.33817e+03     -9.79e-09
## polygon 472 (hole)       18 -4.29008e+04     -4.50e-08
## polygon 473 (hole)        5 -2.69246e+03     -2.82e-09
## polygon 474 (hole)        4 -1.42827e+04     -1.50e-08
## polygon 475 (hole)       17 -1.16716e+05     -1.22e-07
## polygon 476 (hole)        8 -8.23285e+03     -8.63e-09
## polygon 477 (hole)        4 -1.06900e+03     -1.12e-09
## polygon 478 (hole)        3 -4.75092e+01     -4.98e-11
## polygon 479 (hole)       18 -2.34085e+05     -2.45e-07
## polygon 480 (hole)        4 -3.63154e+04     -3.81e-08
## polygon 481 (hole)       18 -4.76834e+05     -5.00e-07
## polygon 482 (hole)        4 -7.30122e+02     -7.65e-10
## polygon 483 (hole)       40 -3.35267e+05     -3.51e-07
## polygon 484 (hole)        3 -9.44905e+02     -9.91e-10
## polygon 485 (hole)        4 -2.55319e+05     -2.68e-07
## polygon 486 (hole)       14 -6.51722e+03     -6.83e-09
## polygon 487 (hole)        3 -1.53312e+02     -1.61e-10
## polygon 488 (hole)       11 -8.19893e+04     -8.59e-08
## polygon 489 (hole)       26 -2.80074e+04     -2.94e-08
## polygon 490 (hole)       17 -3.64026e+04     -3.82e-08
## polygon 491 (hole)        4 -5.16639e+02     -5.42e-10
## polygon 492 (hole)       22 -1.11150e+06     -1.17e-06
## polygon 493 (hole)       14 -3.43429e+05     -3.60e-07
## polygon 494 (hole)       12 -1.89468e+04     -1.99e-08
## polygon 495 (hole)        4 -6.86011e+04     -7.19e-08
## polygon 496 (hole)        4 -4.24399e+04     -4.45e-08
```

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## polygon 497 (hole)       19 -1.42324e+06     -1.49e-06
## polygon 498 (hole)        5 -6.61011e+04     -6.93e-08
## polygon 499 (hole)        4 -4.58492e+03     -4.81e-09
## polygon 500 (hole)        9 -3.03962e+04     -3.19e-08
## polygon 501 (hole)       36 -3.78385e+06     -3.97e-06
## polygon 502 (hole)        4 -8.00200e+00     -8.39e-12
## polygon 503 (hole)        8 -3.78834e+04     -3.97e-08
## polygon 504 (hole)        4 -6.95505e+03     -7.29e-09
## polygon 505 (hole)        4 -8.15524e+07     -8.55e-05
## polygon 506 (hole)        9 -1.44963e+05     -1.52e-07
## polygon 507 (hole)        5 -2.43903e+04     -2.56e-08
## polygon 508 (hole)       11 -3.48574e+04     -3.65e-08
## polygon 509 (hole)       11 -7.58697e+04     -7.95e-08
## polygon 510 (hole)        4 -8.00122e+05     -8.39e-07
## polygon 511 (hole)        6 -2.77612e+03     -2.91e-09
## polygon 512 (hole)        4 -4.01740e+04     -4.21e-08
## polygon 513 (hole)       15 -1.68033e+04     -1.76e-08
## polygon 514 (hole)       15 -2.93750e+06     -3.08e-06
## polygon 515 (hole)        6 -1.69760e+02     -1.78e-10
## polygon 516 (hole)       18 -3.84850e+04     -4.03e-08
## polygon 517 (hole)        7 -2.07236e+03     -2.17e-09
## polygon 518 (hole)        8 -7.34009e+03     -7.69e-09
## polygon 519 (hole)       13 -1.36208e+04     -1.43e-08
## polygon 520 (hole)        3 -4.78678e+02     -5.02e-10
## polygon 521 (hole)       14 -1.34872e+05     -1.41e-07
## polygon 522               9  2.00009e+04      2.10e-08
## polygon 523 (hole)        8 -2.51752e+03     -2.64e-09
## polygon 524 (hole)        4 -1.29042e+04     -1.35e-08
## polygon 525 (hole)        3 -2.28313e+03     -2.39e-09
## polygon 526 (hole)       12 -3.02970e+04     -3.18e-08
## polygon 527 (hole)        9 -1.22910e+05     -1.29e-07
## polygon 528 (hole)        7 -1.73997e+04     -1.82e-08
## polygon 529 (hole)       12 -5.42246e+04     -5.68e-08
## polygon 530 (hole)       16 -7.62604e+05     -7.99e-07
## polygon 531 (hole)        4 -1.96826e+03     -2.06e-09
## polygon 532 (hole)        6 -2.04402e+03     -2.14e-09
## polygon 533 (hole)       28 -4.29550e+05     -4.50e-07
## polygon 534 (hole)        4 -1.95894e+02     -2.05e-10
## polygon 535 (hole)       21 -6.41932e+05     -6.73e-07
## polygon 536 (hole)        4 -1.10982e+03     -1.16e-09
## polygon 537 (hole)        4 -4.96110e+02     -5.20e-10
## polygon 538 (hole)        4 -8.71304e+02     -9.13e-10
## polygon 539 (hole)        4 -5.52027e+03     -5.79e-09
## polygon 540 (hole)        4 -5.96791e+04     -6.26e-08
## polygon 541 (hole)        4 -2.86359e+03     -3.00e-09
## polygon 542 (hole)       16 -1.98274e+05     -2.08e-07
## polygon 543 (hole)        4 -8.25021e+02     -8.65e-10
## polygon 544 (hole)        3 -5.47203e+02     -5.74e-10
## polygon 545 (hole)        8 -1.30232e+04     -1.37e-08
## polygon 546 (hole)        7 -3.60174e+04     -3.78e-08
## polygon 547 (hole)        6 -5.49212e+03     -5.76e-09
## polygon 548 (hole)        5 -2.76715e+03     -2.90e-09
## polygon 549 (hole)       13 -6.39154e+04     -6.70e-08
## polygon 550 (hole)        3 -9.78543e+00     -1.03e-11
```

```
## polygon 551 (hole)       10 -2.34403e+04     -2.46e-08
## polygon 552 (hole)       10 -4.43751e+05     -4.65e-07
## polygon 553 (hole)        8 -6.04669e+03     -6.34e-09
## polygon 554 (hole)        3 -2.47003e-01     -2.59e-13
## polygon 555 (hole)        4 -7.72831e+02     -8.10e-10
## polygon 556 (hole)       21 -1.72424e+04     -1.81e-08
## polygon 557 (hole)        4 -4.17784e+03     -4.38e-09
## polygon 558 (hole)        3 -1.82938e+03     -1.92e-09
## polygon 559 (hole)        3 -3.63300e+04     -3.81e-08
## polygon 560 (hole)       14 -6.48679e+03     -6.80e-09
## polygon 561 (hole)        4 -7.64075e+02     -8.01e-10
## polygon 562 (hole)        4 -9.66991e+03     -1.01e-08
## polygon 563 (hole)       13 -4.59494e+03     -4.82e-09
## polygon 564 (hole)       16 -1.80540e+06     -1.89e-06
## polygon 565 (hole)        4 -5.52193e+03     -5.79e-09
## polygon 566 (hole)        4 -2.36699e+03     -2.48e-09
## polygon 567 (hole)        5 -5.34099e+04     -5.60e-08
## polygon 568 (hole)       33 -2.61795e+04     -2.74e-08
## polygon 569 (hole)       15 -3.05512e+04     -3.20e-08
## polygon 570 (hole)        4 -4.20308e+03     -4.41e-09
## polygon 571 (hole)       12 -8.35767e+04     -8.76e-08
## polygon 572 (hole)        3 -9.92830e+03     -1.04e-08
## polygon 573 (hole)        4 -6.13728e+03     -6.43e-09
## polygon 574 (hole)        9 -2.32282e+05     -2.43e-07
## polygon 575 (hole)        8 -1.04331e+04     -1.09e-08
## polygon 576 (hole)        3 -3.78786e+04     -3.97e-08
## polygon 577 (hole)        3 -6.62996e+03     -6.95e-09
## polygon 578 (hole)        7 -9.24974e+05     -9.70e-07
## polygon 579 (hole)       24 -1.65888e+05     -1.74e-07
## polygon 580 (hole)        4 -1.31213e+04     -1.38e-08
## polygon 581 (hole)        3 -8.95591e+02     -9.39e-10
## polygon 582 (hole)        7 -1.55656e+06     -1.63e-06
## polygon 583 (hole)        6 -5.65494e+04     -5.93e-08
## polygon 584 (hole)        4 -3.54232e+02     -3.71e-10
## polygon 585 (hole)       20 -2.27942e+04     -2.39e-08
## polygon 586 (hole)       12 -5.62590e+04     -5.90e-08
## polygon 587 (hole)        8 -2.65635e+03     -2.78e-09
## polygon 588 (hole)       11 -7.99485e+04     -8.38e-08
## polygon 589 (hole)        4 -5.04281e+03     -5.29e-09
## polygon 590 (hole)        5 -4.57783e+03     -4.80e-09
## polygon 591 (hole)        4 -2.64068e+03     -2.77e-09
## polygon 592 (hole)       21 -5.25564e+05     -5.51e-07
## polygon 593 (hole)        5 -2.22516e+04     -2.33e-08
## polygon 594 (hole)        4 -2.12500e+06     -2.23e-06
## polygon 595 (hole)        5 -1.26124e+04     -1.32e-08
## polygon 596 (hole)        4 -4.76115e+02     -4.99e-10
## polygon 597 (hole)       19 -1.36345e+06     -1.43e-06
## polygon 598 (hole)       13 -2.18637e+04     -2.29e-08
## polygon 599 (hole)        7 -3.01056e+04     -3.16e-08
## polygon 600 (hole)       10 -3.92618e+03     -4.12e-09
## polygon 601 (hole)       11 -9.05052e+03     -9.49e-09
## polygon 602 (hole)        7 -6.13831e+02     -6.43e-10
## polygon 603 (hole)        9 -7.69151e+02     -8.06e-10
## polygon 604 (hole)        3 -5.98331e+03     -6.27e-09
```

```
## polygon 605 (hole)        4 -2.60127e+03     -2.73e-09
## polygon 606 (hole)       13 -4.86651e+03     -5.10e-09
## polygon 607 (hole)        4 -9.62035e+03     -1.01e-08
## polygon 608 (hole)        6 -1.50305e+04     -1.58e-08
## polygon 609 (hole)        8 -1.48236e+05     -1.55e-07
## polygon 610 (hole)       12 -5.05397e+02     -5.30e-10
## polygon 611 (hole)        4 -1.32119e+02     -1.38e-10
## polygon 612 (hole)        3 -1.77186e+02     -1.86e-10
## polygon 613 (hole)        8 -6.83704e+01     -7.17e-11
## polygon 614 (hole)        4 -3.64953e+02     -3.83e-10
## polygon 615 (hole)        4 -2.51137e+03     -2.63e-09
## polygon 616 (hole)       15 -1.24106e+04     -1.30e-08
## polygon 617 (hole)       10 -2.52771e+03     -2.65e-09
## polygon 618 (hole)       22 -5.47865e+05     -5.74e-07
## polygon 619 (hole)        5 -9.60147e+01     -1.01e-10
## polygon 620 (hole)       16 -1.80813e+03     -1.90e-09
## polygon 621 (hole)        4 -4.51015e+02     -4.73e-10
## polygon 622 (hole)        4 -1.23899e+03     -1.30e-09
## polygon 623 (hole)        4 -2.65512e+04     -2.78e-08
## polygon 624 (hole)        4 -1.50605e+02     -1.58e-10
## polygon 625 (hole)        4 -5.01527e+04     -5.26e-08
## polygon 626 (hole)        7 -1.00689e+03     -1.06e-09
## polygon 627 (hole)       10 -1.35101e+03     -1.42e-09
## polygon 628 (hole)        8 -7.32828e+02     -7.68e-10
## polygon 629 (hole)       11 -1.00016e+03     -1.05e-09
## polygon 630 (hole)        6 -1.75765e+01     -1.84e-11
## polygon 631 (hole)        7 -1.28097e+03     -1.34e-09
## polygon 632 (hole)        6 -1.07071e+04     -1.12e-08
## polygon 633 (hole)        3 -1.56575e+00     -1.64e-12
## polygon 634 (hole)        3 -5.04425e+01     -5.29e-11
## polygon 635 (hole)        4 -7.08310e+02     -7.42e-10
## polygon 636 (hole)        4 -4.79035e+03     -5.02e-09
## polygon 637 (hole)        6 -3.46985e+02     -3.64e-10
## polygon 638 (hole)        9 -8.66888e+02     -9.09e-10
## polygon 639 (hole)        5 -2.55069e+03     -2.67e-09
## polygon 640 (hole)        6 -8.40047e+00     -8.81e-12
## polygon 641 (hole)        3 -1.98807e+04     -2.08e-08
## polygon 642 (hole)       11 -1.49501e+04     -1.57e-08
## polygon 643 (hole)        7 -1.91608e+03     -2.01e-09
## polygon 644 (hole)        4 -4.55803e+02     -4.78e-10
## polygon 645 (hole)        8 -4.43366e+03     -4.65e-09
## polygon 646 (hole)        3 -4.01563e+01     -4.21e-11
## polygon 647 (hole)        3 -9.13318e+02     -9.57e-10
## polygon 648 (hole)        4 -5.90763e+04     -6.19e-08
## polygon 649 (hole)        3 -2.60929e+01     -2.74e-11
## polygon 650 (hole)        3 -2.25831e+03     -2.37e-09
## polygon 651 (hole)       13 -3.07958e+05     -3.23e-07
## polygon 652 (hole)        3 -1.24833e+03     -1.31e-09
## polygon 653 (hole)        6 -1.30872e+05     -1.37e-07
## polygon 654 (hole)       12 -7.82743e+03     -8.21e-09
## polygon 655 (hole)        9 -1.52443e+04     -1.60e-08
## polygon 656 (hole)        4 -1.61193e+05     -1.69e-07
## polygon 657 (hole)        3 -1.71824e+03     -1.80e-09
## polygon 658 (hole)       18 -2.56830e+05     -2.69e-07
```

```
## polygon 659 (hole)        3 -3.17483e+04     -3.33e-08
## polygon 660 (hole)       15 -3.10723e+05     -3.26e-07
## polygon 661 (hole)        3 -5.26655e+02     -5.52e-10
## polygon 662 (hole)        4 -5.59633e+03     -5.87e-09
## polygon 663 (hole)        4 -6.74954e+05     -7.08e-07
## polygon 664 (hole)        3 -1.00323e+00     -1.05e-12
## polygon 665 (hole)        3 -1.27789e+02     -1.34e-10
## polygon 666 (hole)        4 -1.89979e+03     -1.99e-09
## polygon 667 (hole)        4 -6.95906e+03     -7.29e-09
## polygon 668 (hole)        4 -4.02591e+03     -4.22e-09
## polygon 669 (hole)        4 -6.28375e+03     -6.59e-09
## polygon 670 (hole)        4 -1.95737e+04     -2.05e-08
## polygon 671 (hole)        4 -1.09114e+04     -1.14e-08
## polygon 672 (hole)        4 -2.11420e+02     -2.22e-10
## polygon 673 (hole)        4 -4.44414e+04     -4.66e-08
## polygon 674 (hole)        5 -3.26337e+08     -3.42e-04
## polygon 675 (hole)        4 -1.80487e+05     -1.89e-07
## polygon 676 (hole)       11 -2.40141e+05     -2.52e-07
## polygon 677 (hole)       16 -2.84043e+05     -2.98e-07
## polygon 678 (hole)        8 -4.51231e+05     -4.73e-07
## polygon 679 (hole)        4 -1.35847e+03     -1.42e-09
## polygon 680 (hole)       18 -2.66394e+05     -2.79e-07
## polygon 681 (hole)        8 -2.98585e+05     -3.13e-07
## polygon 682 (hole)        3 -5.58598e+04     -5.86e-08
## polygon 683 (hole)        8 -2.69865e+05     -2.83e-07
## polygon 684 (hole)        4 -7.10459e+04     -7.45e-08
## polygon 685 (hole)        4 -1.38659e+03     -1.45e-09
## polygon 686 (hole)        4 -5.84763e+02     -6.13e-10
## polygon 687 (hole)        7 -1.15732e+04     -1.21e-08
## polygon 688 (hole)        4 -1.93415e+03     -2.03e-09
## polygon 689 (hole)        9 -4.92164e+08     -5.16e-04
## polygon 690 (hole)        4 -5.92390e-01     -6.21e-13
## polygon 691 (hole)        4 -1.27544e+04     -1.34e-08
## polygon 692 (hole)        4 -2.69837e+03     -2.83e-09
## polygon 693 (hole)        3 -7.43812e+02     -7.80e-10
## polygon 694 (hole)        4 -1.52772e+03     -1.60e-09
## polygon 695 (hole)        4 -1.83492e+05     -1.92e-07
## polygon 696 (hole)        3 -8.14239e+04     -8.54e-08
## polygon 697 (hole)        8 -3.15155e+07     -3.30e-05
## polygon 698 (hole)       15 -1.28380e+08     -1.35e-04
## polygon 699 (hole)        4 -2.01771e+06     -2.12e-06
## polygon 700 (hole)       14 -2.17326e+08     -2.28e-04
## polygon 701 (hole)       10 -2.84969e+08     -2.99e-04
## polygon 702 (hole)        5 -3.04491e+08     -3.19e-04
## polygon 703 (hole)        4 -5.20498e+07     -5.46e-05
## polygon 704 (hole)        5 -2.19617e+07     -2.30e-05
## polygon 705 (hole)       10 -5.40059e+07     -5.66e-05
## polygon 706 (hole)        4 -5.83174e+04     -6.11e-08
## polygon 707 (hole)        8 -5.21801e+07     -5.47e-05
## polygon 708 (hole)       32 -2.83616e+07     -2.97e-05
## polygon 709 (hole)        4 -1.16415e+07     -1.22e-05
## polygon 710 (hole)        5 -2.27768e+08     -2.39e-04
## polygon 711 (hole)        9 -3.24071e+07     -3.40e-05
## polygon 712 (hole)        4 -1.73500e+06     -1.82e-06
```

```
## polygon 713 (hole)        4 -5.11077e+07     -5.36e-05
## polygon 714 (hole)        3 -1.51775e+01     -1.59e-11
## polygon 715 (hole)        8 -7.42871e+06     -7.79e-06
## polygon 716 (hole)        4 -3.41025e+06     -3.57e-06
## polygon 717 (hole)        4 -9.56070e+05     -1.00e-06
## polygon 718 (hole)        8 -1.17876e+07     -1.24e-05
## polygon 719 (hole)        4 -1.73147e+06     -1.82e-06
## polygon 720 (hole)       12 -3.21396e+07     -3.37e-05
## polygon 721 (hole)        3 -8.91333e+05     -9.34e-07
## polygon 722 (hole)        4 -3.12975e+05     -3.28e-07
## polygon 723 (hole)       12 -3.01383e+07     -3.16e-05
## polygon 724 (hole)        5 -5.31437e+06     -5.57e-06
## polygon 725 (hole)        5 -3.47938e+07     -3.65e-05
## polygon 726 (hole)        4 -5.01715e+06     -5.26e-06
## polygon 727 (hole)       11 -1.50586e+07     -1.58e-05
## polygon 728 (hole)       15 -8.23774e+07     -8.64e-05
## polygon 729 (hole)        8 -2.94379e+06     -3.09e-06
## polygon 730 (hole)        8 -1.85483e+06     -1.94e-06
## polygon 731 (hole)        7 -5.10598e+07     -5.35e-05
## polygon 732 (hole)        4 -1.07925e+05     -1.13e-07
## polygon 733 (hole)        4 -1.00174e+08     -1.05e-04
## polygon 734 (hole)       25 -7.47022e+07     -7.83e-05
## polygon 735 (hole)       11 -2.04679e+06     -2.15e-06
## polygon 736 (hole)       13 -4.74913e+06     -4.98e-06
## polygon 737 (hole)        4 -1.14394e+06     -1.20e-06
## polygon 738 (hole)        6 -9.02448e+07     -9.46e-05
## polygon 739 (hole)       12 -1.38671e+08     -1.45e-04
## polygon 740 (hole)        4 -1.03674e+05     -1.09e-07
## polygon 741               4  2.21230e+09      2.32e-03
## polygon 742 (hole)        4 -2.67287e+07     -2.80e-05
## polygon 743 (hole)        4 -1.05917e+08     -1.11e-04
## polygon 744 (hole)        3 -1.86317e+05     -1.95e-07
## polygon 745 (hole)       14 -4.67330e+07     -4.90e-05
## polygon 746 (hole)       11 -6.01208e+07     -6.30e-05
## polygon 747 (hole)        4 -4.99799e+06     -5.24e-06
## polygon 748 (hole)       12 -1.36321e+08     -1.43e-04
## polygon 749 (hole)       12 -1.58096e+07     -1.66e-05
## polygon 750 (hole)        5 -2.78899e+06     -2.92e-06
## polygon 751 (hole)       20 -4.08867e+08     -4.29e-04
## polygon 752 (hole)        5 -1.17574e+09     -1.23e-03
## polygon 753 (hole)        7 -1.40083e+06     -1.47e-06
## polygon 754 (hole)        7 -1.56368e+08     -1.64e-04
## polygon 755 (hole)        9 -1.96541e+06     -2.06e-06
## polygon 756 (hole)        9 -2.95723e+06     -3.10e-06
## polygon 757 (hole)       17 -1.37154e+06     -1.44e-06
## polygon 758 (hole)        8 -2.47366e+05     -2.59e-07
## polygon 759 (hole)        7 -5.04362e+04     -5.29e-08
## polygon 760 (hole)        4 -8.97986e+04     -9.41e-08
## polygon 761 (hole)        3 -2.69099e+05     -2.82e-07
## polygon 762 (hole)        3 -5.78389e+05     -6.06e-07
## enclosing rectangle: [1001725.9, 2695828.1] x [237157.1, 1715293.5] units
##                      (1694000 x 1478000 units)
## Window area = 9.53963e+11 square units
## Fraction of frame area: 0.381
```

```
##
## *** 34 illegal points stored in attr(,"rejects") ***
```

```
intensity(vulpes_ppp)
```

```
## [1] 5.063089e-10
```

Per the summary, Average intensity 5.063089e-10 points per square unit which is 0.0000000005063089 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(vulpes_ppp,
                  nx = 5,
                  ny = 5)

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

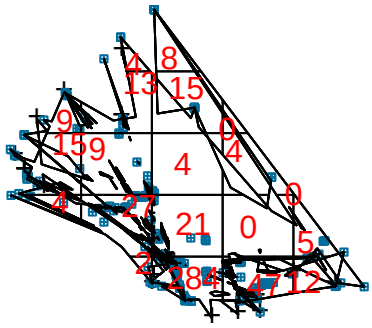
```
## Warning in plot.ppp(vulpes_ppp, pch = 12, cex = 0.5, cols = "#046C9A", main =
## "Vulpes Vulpes locations"): 34 illegal points also plotted
```

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

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

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

Vulpes Vulpes locations

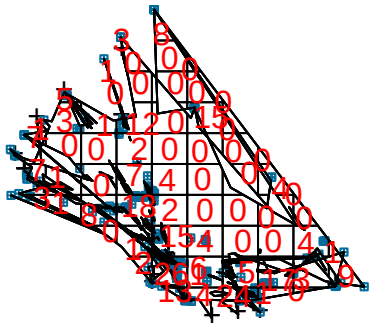



```
plot(vulpes_ppp,
     pch = 12,
     cex = 0.5,
     cols = "#046C9A",
     main = "Beilschmiedia pendula locations")
```

```
## Warning in plot.ppp(vulpes_ppp, pch = 12, cex = 0.5, cols = "#046C9A", main =
## "Beilschmiedia pendula locations"): 34 illegal points also plotted
```

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

Beilschmiedia pendula location



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 = 7401.1, df = 64, p-value < 2.2e-16
## alternative hypothesis: two.sided
##
## Quadrats: 65 tiles (irregular windows)
```

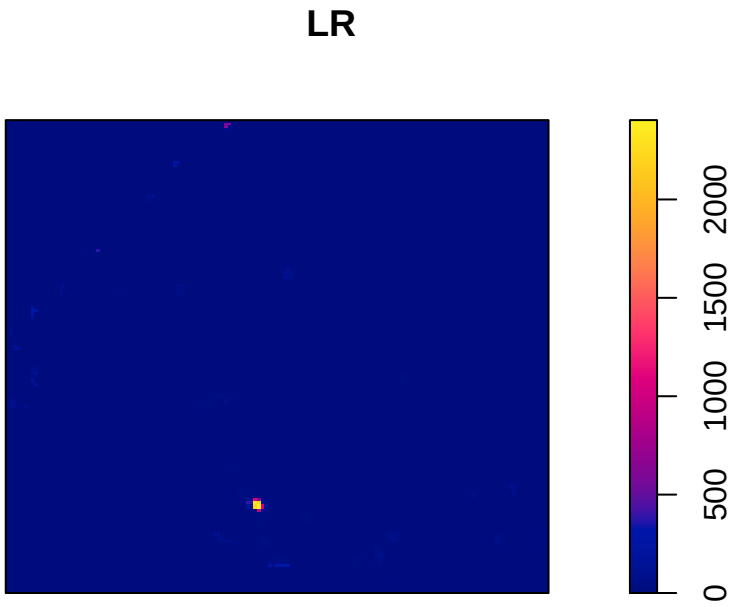
The null hypothesis of the test suggests homogeneity in the process and as the p-value is very small, the null hypothesis is rejected and its confirmed there is significant deviation from homogeneity.

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(vulpes_ppp)
```

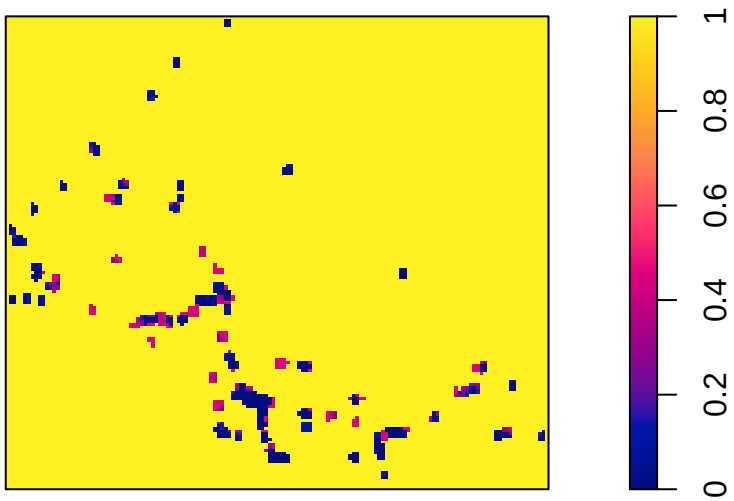
```r
#Calculate test statistic
LR <- scanLRTS(vulpes_ppp, r = R)

#Plot the output
plot(LR)
```




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


#Plot the output
plot(pvals, main = "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
vulpes_ppp <- ppp(x = data.sp_trans$decimalLatitude, # X coordinates
                  y = data.sp_trans$decimalLongitude)
```

```
## Warning: 517 points were rejected as lying outside the specified window
```

```
#.....
```