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
```

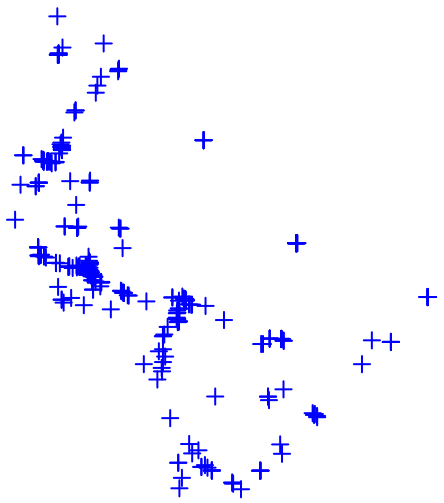
```
library(raster)
```

```
## 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
```

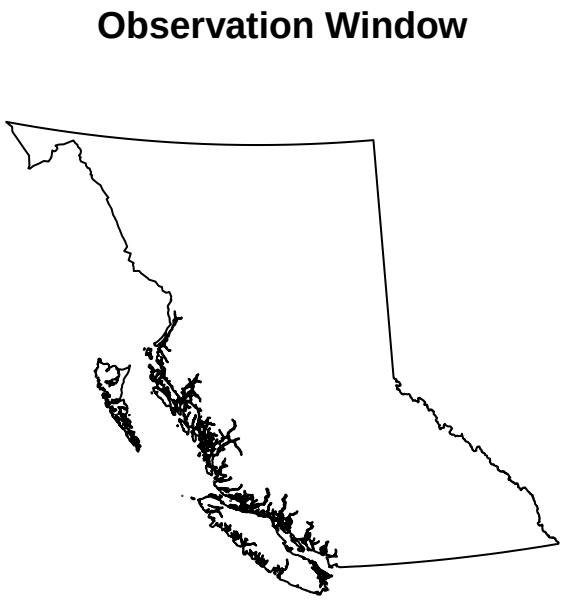
```
## Loading required package: spatstat.random
```

```
## 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'
```

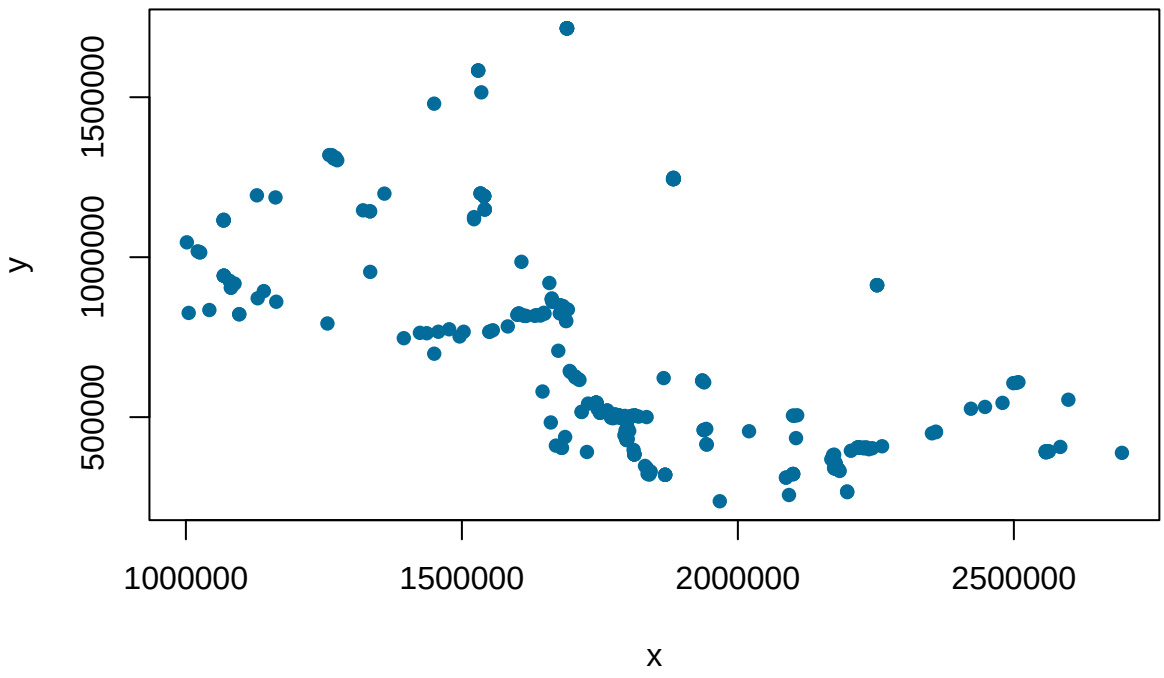
```
library(maptools)
```

```
## 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
```

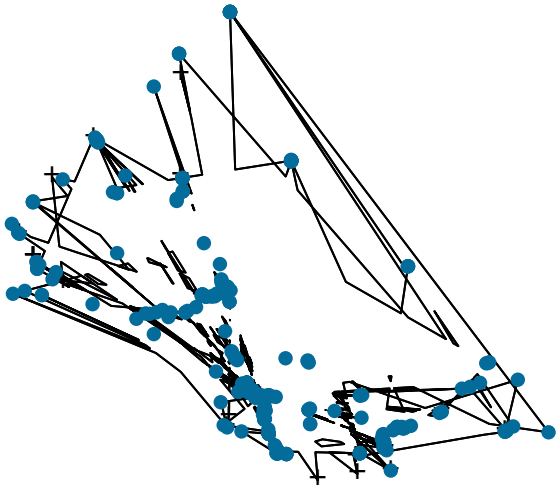
```
## Warning: point-in-polygon test had difficulty with 9 points (total score not 0
## or 1)
```

```
## 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
```




```
#Estimate intensity by hand
library(maptools)
library(spatstat)
library('sp')
library('raster')
#area(Window(bei))
intensity(bei)
```

```
## [1] 0.007208
```

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
```

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## 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
## 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
```

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## 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
## 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
```

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## 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
## 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
```

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## 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
## 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
```

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## 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
## 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
```

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## 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
## 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
```

```
#area(Window(vulpes_ppp))
```

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: 3 by 3 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.

```
#Split into a 3 by 3 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")
```

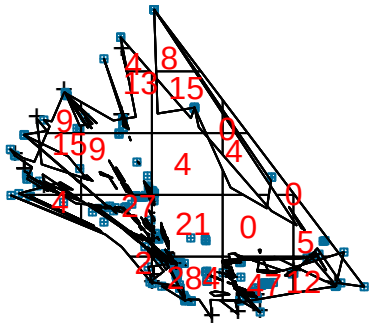
```
## Warning in plot.ppp(vulpes_ppp, pch = 12, cex = 0.5, cols = "#046C9A", main =
## "Vulpes Vulpes locations"): 34 illegal points also plotted
```

```
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

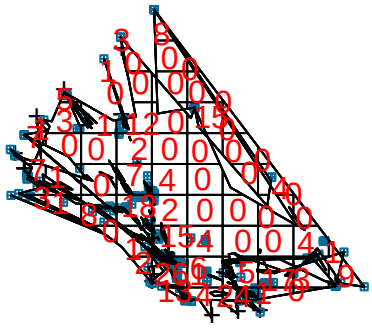



```
plot(vulpes_ppp,
     pch = 12,
     cex = 0.5,
     cols = "#046C9A",
     main = "Beilschmiedia pendula locations")
```

```
## 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



```
#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
```

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