

Mining Spatial Data

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Raster = data gambar

```
load("C:/Users/PC 11/OneDrive - Universiti Kebangsaan Malaysia/Data-Mining/11. Mining Spatial Data/wst.l  
attach(wst)
```

```
## The following object is masked from package:datasets:  
##  
##      precip
```

```
library(sp)  
library(raster)
```

```
## Warning: package 'raster' was built under R version 4.4.2
```

```
wst
```

```
##      longitude latitude name precip
## 1      -116.7     45.3    A     721
## 2      -120.4     42.6    B      19
## 3      -116.7     38.9    C      52
## 4      -113.5     42.1    D     188
## 5      -115.5     35.7    E     749
## 6      -120.8     38.9    F       8
## 7      -119.5     36.2    G     725
## 8      -113.7     39.0    H     843
## 9      -113.7     41.6    I     289
## 10     -110.7     36.9    J     249
```

define spatial data

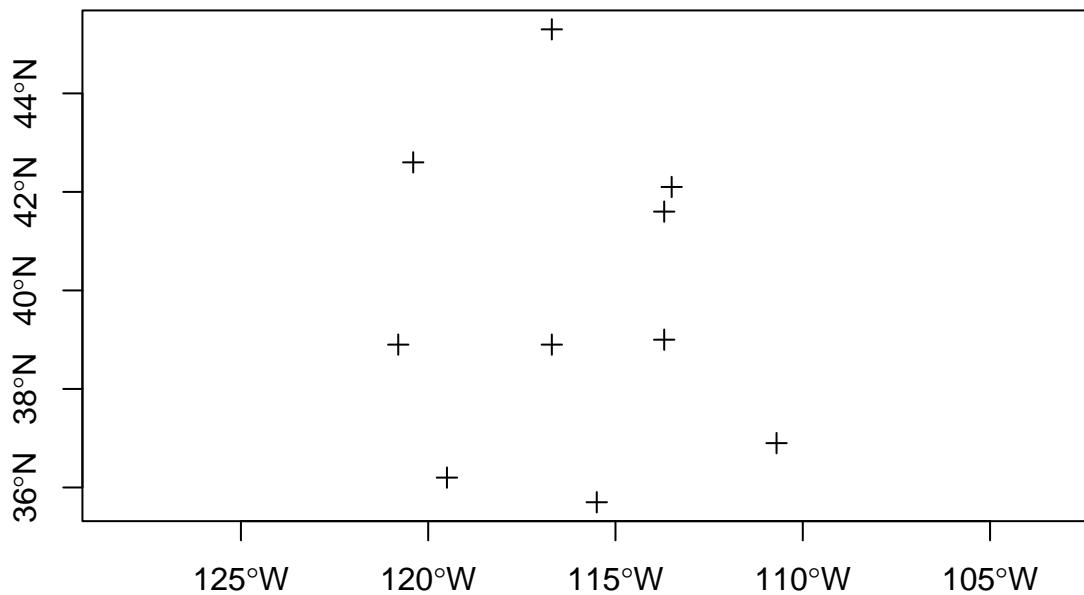
```
lonlat = cbind(longitude, latitude)
pts = SpatialPoints(lonlat)
```

define crs in spatial data

```
crdref = CRS('+proj=longlat + datum=WGS84')
pts = SpatialPoints(lonlat, proj4string = crdref)
```

Insert feature or variable

```
df = data.frame(ID=name, precip)
ptsdf = SpatialPointsDataFrame(pts, data=df)
plot(ptsdf, axes = T)
```



```
showDefault(ptsdf)
```

```
## An object of class "SpatialPointsDataFrame"
## Slot "data":
##      ID precip
## 1    A     721
## 2    B      19
## 3    C      52
## 4    D     188
## 5    E     749
## 6    F       8
## 7    G     725
## 8    H     843
## 9    I     289
## 10   J     249
##
## Slot "coords.nrs":
## numeric(0)
##
## Slot "coords":
##      longitude latitude
## [1,]    -116.7     45.3
## [2,]    -120.4     42.6
## [3,]    -116.7     38.9
## [4,]    -113.5     42.1
```

```

## [5,]    -115.5    35.7
## [6,]    -120.8    38.9
## [7,]    -119.5    36.2
## [8,]    -113.7    39.0
## [9,]    -113.7    41.6
## [10,]   -110.7    36.9
##
## Slot "bbox":
##           min      max
## longitude -120.8 -110.7
## latitude   35.7   45.3
##
## Slot "proj4string":
## Coordinate Reference System:
## Deprecated Proj.4 representation: +proj=longlat +datum=WGS84 +no_defs
## WKT2 2019 representation:
## GEOGCRS["unknown",
##   DATUM["World Geodetic System 1984",
##     ELLIPSOID["WGS 84",6378137,298.257223563,
##       LENGTHUNIT["metre",1]],
##     ID["EPSG",6326]],
##   PRIMEM["Greenwich",0,
##     ANGLEUNIT["degree",0.0174532925199433],
##     ID["EPSG",8901]],
##   CS[ellipsoidal,2],
##     AXIS["longitude",east,
##       ORDER[1],
##       ANGLEUNIT["degree",0.0174532925199433,
##         ID["EPSG",9122]]],
##     AXIS["latitude",north,
##       ORDER[2],
##       ANGLEUNIT["degree",0.0174532925199433,
##         ID["EPSG",9122]]]]

```

```

lon = c(-116.8, -114.2, -112.9, -111.9, -114.2, -115.4, -117.7)

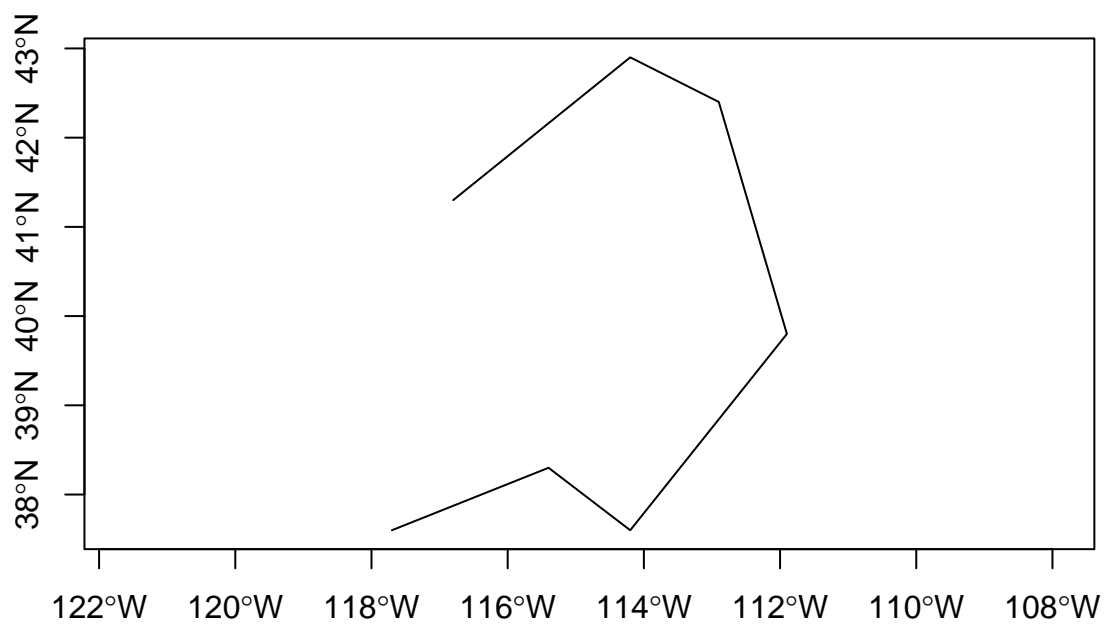
lat = c(41.3, 42.9, 42.4, 39.8, 37.6, 38.3, 37.6)

lonlat = cbind(lon, lat)

lns = spLines(lonlat, crs=crdref)

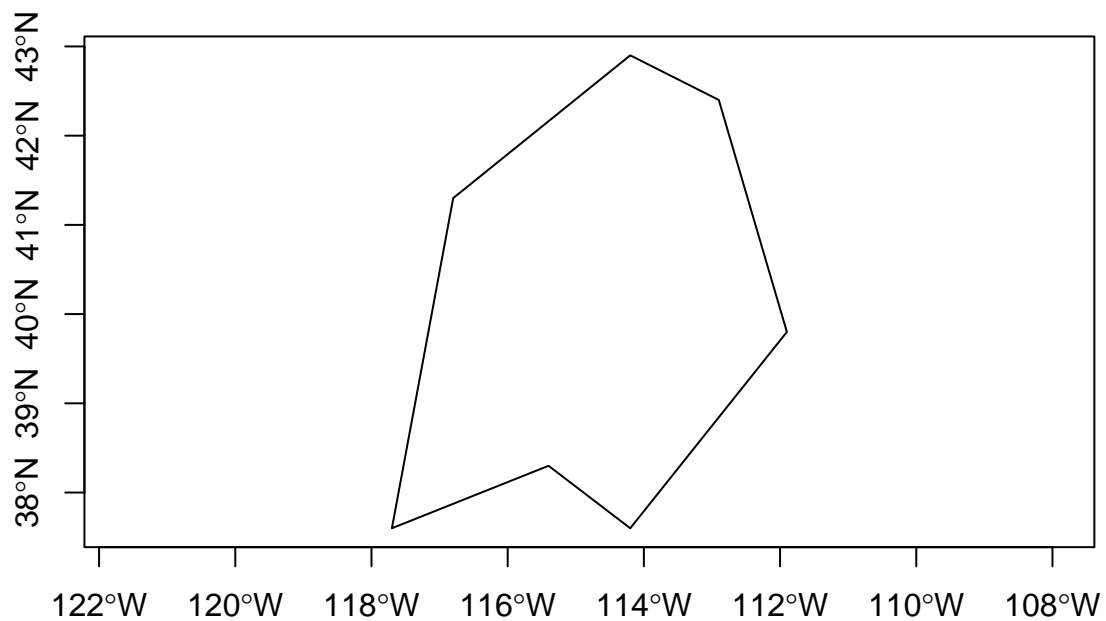
plot(lns, axes=T)

```



Polygon

```
pols = spPolygons(lonlat, crs=crdref)
plot(pols, axes = T)
```



Raster

```
r = raster(ncol = 20, nrow=20, xmx=-80, xmn=-150, ymn=20, ymx=60)

x = rexp(ncell(r))

values(r) = x

showDefault(r)
```

```
## An object of class "RasterLayer"
## Slot "file":
## An object of class ".RasterFile"
## Slot "name":
## [1] ""
##
## Slot "datanotation":
## [1] "FLT4S"
##
## Slot "byteorder":
## [1] "little"
##
## Slot "nodatavalue":
```

```

## [1] -Inf
##
## Slot "NAchanged":
## [1] FALSE
##
## Slot "nbands":
## [1] 1
##
## Slot "bandorder":
## [1] "BIL"
##
## Slot "offset":
## [1] 0
##
## Slot "toptobottom":
## [1] TRUE
##
## Slot "blockrows":
## [1] 0
##
## Slot "blockcols":
## [1] 0
##
## Slot "driver":
## [1] ""
##
## Slot "open":
## [1] FALSE
##
##
## Slot "data":
## An object of class ".SingleLayerData"
## Slot "values":
## [1] 0.823505371 0.656421524 1.615507807 0.414180835 0.215982257 1.670737224
## [7] 2.376786331 0.490528088 0.110465127 0.919439176 0.190412631 2.074331319
## [13] 0.662385634 1.965305220 0.114952337 3.836318703 0.153614915 1.351927319
## [19] 0.844468297 1.562000902 0.744654586 1.040399253 0.225926930 2.323188532
## [25] 1.813416636 0.102364829 1.370122882 0.067698535 0.533300482 0.512469860
## [31] 0.278273402 0.041891114 0.192927939 4.049653044 0.553746619 0.087528263
## [37] 2.001019580 1.875396220 0.888111414 3.438507303 0.633382638 0.172434056
## [43] 1.972179355 0.482474166 2.154732121 0.149930332 1.301216612 0.214814000
## [49] 0.474971090 0.098243551 1.490754576 1.154209752 0.240018635 0.474764608
## [55] 0.081812392 1.580846637 0.799822947 2.315673789 0.260778524 1.558384847
## [61] 0.141460607 0.203081524 0.466205087 1.434552818 0.348668965 0.921195642
## [67] 0.182698790 0.142114436 0.457589308 2.716751939 3.588262826 0.374849531
## [73] 0.346755249 1.388863852 0.341615783 0.285613055 2.986536398 3.032713802
## [79] 1.677220309 0.454691820 0.982040143 0.663267357 0.353409418 2.526270272
## [85] 1.307146287 2.079457082 3.473819887 0.682804552 1.287725250 0.142748618
## [91] 1.490433652 1.375195192 0.658257311 1.289732949 1.574541207 7.548712235
## [97] 0.991767896 0.228218774 0.945895302 0.518682617 2.135975908 0.320126843
## [103] 0.076037067 0.293049926 1.748321598 4.234910596 0.139997157 0.797865840
## [109] 0.538900035 1.076773777 0.712591056 0.466132159 2.260929091 0.015743660
## [115] 0.959925331 0.208142876 0.924905042 0.926234317 1.275599182 1.785364811
## [121] 2.249355528 0.080946139 1.932255702 0.695639163 6.507827503 1.087496535

```

```

## [127] 0.185180872 1.015314630 0.657397467 0.425448574 1.355258219 0.442159491
## [133] 2.422924691 0.833668420 5.134267794 0.203882882 0.466426835 0.655791477
## [139] 0.139954251 0.030644334 0.931536518 0.214121386 0.808940929 0.007270595
## [145] 1.082752423 0.736386958 0.501366176 1.681812245 0.904215942 2.593597999
## [151] 1.268975862 1.080782069 1.534253158 1.337038359 0.224938236 0.312269740
## [157] 0.044358026 0.012633026 0.274882760 1.585372930 1.407415220 0.346990572
## [163] 0.480140687 0.739900021 1.471972269 0.293074974 2.148833753 0.694485871
## [169] 2.070724277 0.411414153 0.329347058 1.304828215 0.158735406 3.008016635
## [175] 0.232302320 0.796467158 1.350323121 0.126367560 0.478868040 0.313043407
## [181] 3.399790585 0.529439822 1.283914693 0.215708100 0.800236153 0.247169659
## [187] 0.634591956 0.392171551 1.499880649 1.461992866 0.111256668 2.174029952
## [193] 0.620972493 2.015964268 0.842795409 1.006858452 1.588551606 0.540124158
## [199] 2.285294013 0.120231011 0.551240630 3.745545403 0.302319772 1.002747053
## [205] 0.391566915 0.036038179 0.012569762 0.070643605 0.406998509 0.366419239
## [211] 1.633279305 0.328166316 1.035627400 0.555864796 1.158669271 1.102160623
## [217] 0.066838983 1.830859370 1.154736805 0.094893256 0.585110024 0.801576807
## [223] 1.418264430 0.465611616 1.874281850 0.597770672 1.215270158 0.027698693
## [229] 2.732024131 3.850232160 1.866347933 0.169805531 0.921876193 0.654787451
## [235] 0.342870840 0.728640052 0.025103626 2.261498576 0.300650511 4.110593950
## [241] 0.146434012 1.103345929 0.908107374 1.380088229 2.040010892 0.858682508
## [247] 0.965831010 0.493694521 1.384202511 0.515522920 0.175717061 0.127873719
## [253] 0.337077167 0.218173877 1.019443449 0.778503578 0.514500039 1.248805670
## [259] 0.260321283 0.210649448 0.678782952 2.004682960 0.740920614 0.749090542
## [265] 0.248220296 0.079940942 0.350672498 2.828771121 1.748126213 1.392485384
## [271] 0.159363578 0.375295499 2.622764295 0.368368747 2.427535715 0.086592549
## [277] 1.367491996 0.128734830 1.189784341 0.939555564 1.278391320 1.361046663
## [283] 0.677518809 1.218624746 0.306482926 1.613267637 0.821499817 0.211228237
## [289] 3.144516088 2.026581001 0.448489619 0.187907963 0.063931941 1.104547956
## [295] 0.960561380 1.373887368 0.130267555 0.097245692 1.095399989 1.716063598
## [301] 0.104202793 0.192630757 1.317700202 2.199117107 0.672723843 0.302040705
## [307] 0.689444448 1.287646501 2.272963120 0.191930603 2.213853883 1.438889947
## [313] 0.402602169 3.172764018 0.548404157 1.297839673 0.009385185 1.479292363
## [319] 0.810827612 0.152205181 0.458374219 0.082789882 0.400741497 1.234384624
## [325] 2.403852602 4.153666546 1.402831572 0.497226121 0.368048720 0.017215993
## [331] 1.471881814 1.339393980 0.651318367 0.845738711 0.006753341 1.078902077
## [337] 0.550377052 0.603694970 3.749936797 1.248890266 1.105724231 1.883145027
## [343] 0.077655083 0.166238005 2.678546926 0.438737765 3.050884537 0.335662180
## [349] 0.310659176 1.073405581 0.636456381 0.255710959 0.157981700 1.380218856
## [355] 0.497454320 0.767668404 0.885674249 0.921588644 0.069661721 0.516042650
## [361] 0.220438496 1.582305403 0.034555355 1.591757649 2.560132554 1.019178484
## [367] 1.527522165 0.274311685 1.583708404 0.811784450 0.206496875 0.614962151
## [373] 1.142166055 0.791192487 0.272068070 0.093269661 0.531138944 1.489505204
## [379] 1.372877132 0.171457261 1.625302537 1.561381962 0.028858809 1.259464634
## [385] 0.759174838 0.536324488 0.488392578 0.965368238 0.628920642 0.202166491
## [391] 1.826126294 0.007387443 0.346981733 1.100139831 1.543649709 0.496952444
## [397] 0.780002967 0.480875216 1.628626510 0.797157202
##
## Slot "offset":
## [1] 0
##
## Slot "gain":
## [1] 1
##
## Slot "inmemory":

```



```

## [1] TRUE
##
## Slot "fromdisk":
## [1] FALSE
##
## Slot "isfactor":
## [1] FALSE
##
## Slot "attributes":
## list()
##
## Slot "haveminmax":
## [1] TRUE
##
## Slot "min":
## [1] 0.006753341
##
## Slot "max":
## [1] 7.548712
##
## Slot "band":
## [1] 1
##
## Slot "unit":
## [1] ""
##
## Slot "names":
## [1] ""
##
##
## Slot "legend":
## An object of class ".RasterLegend"
## Slot "type":
## character(0)
##
## Slot "values":
## logical(0)
##
## Slot "color":
## logical(0)
##
## Slot "names":
## logical(0)
##
## Slot "colortable":
## logical(0)
##
##
## Slot "title":
## character(0)
##
## Slot "extent":
## class      : Extent
## xmin       : -150

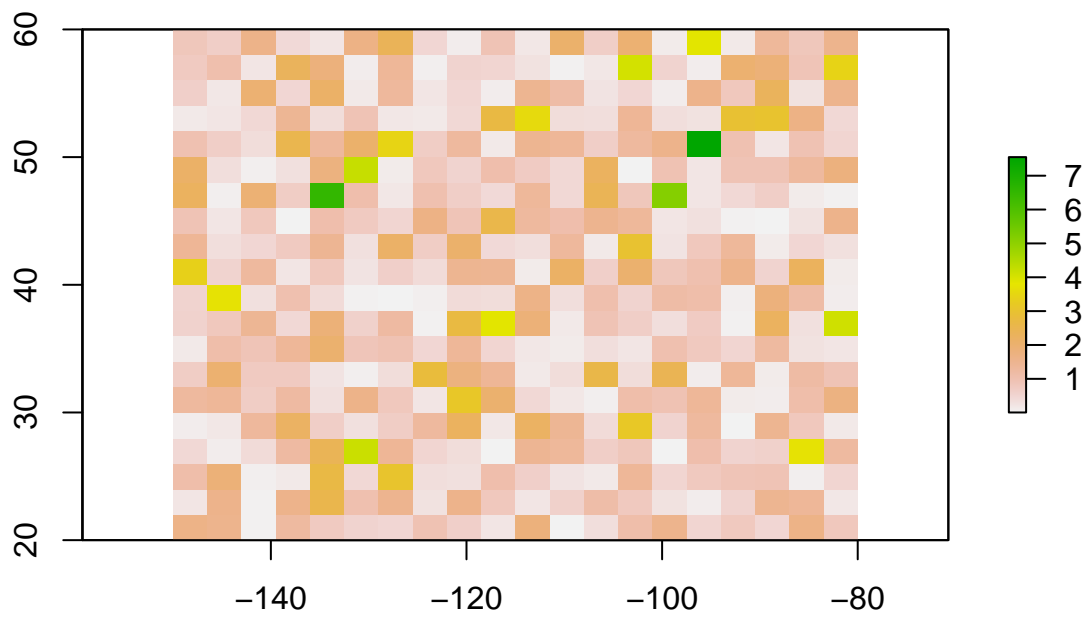
```

```

## xmax      : -80
## ymin      : 20
## ymax      : 60
##
## Slot "rotated":
## [1] FALSE
##
## Slot "rotation":
## An object of class ".Rotation"
## Slot "geotrans":
## numeric(0)
##
## Slot "transfun":
## function ()
## NULL
## <bytecode: 0x000001e65846f820>
##
##
## Slot "ncols":
## [1] 20
##
## Slot "nrows":
## [1] 20
##
## Slot "crs":
## Coordinate Reference System:
## Deprecated Proj.4 representation: NA
##
## Slot "srs":
## [1] "GEOGCRS[\"unknown\", \n    DATUM[\"World Geodetic System 1984\", \n    ELLIPSOID[\"WGS 84\", 63
##
## Slot "history":
## list()
##
## Slot "z":
## list()

plot(r)

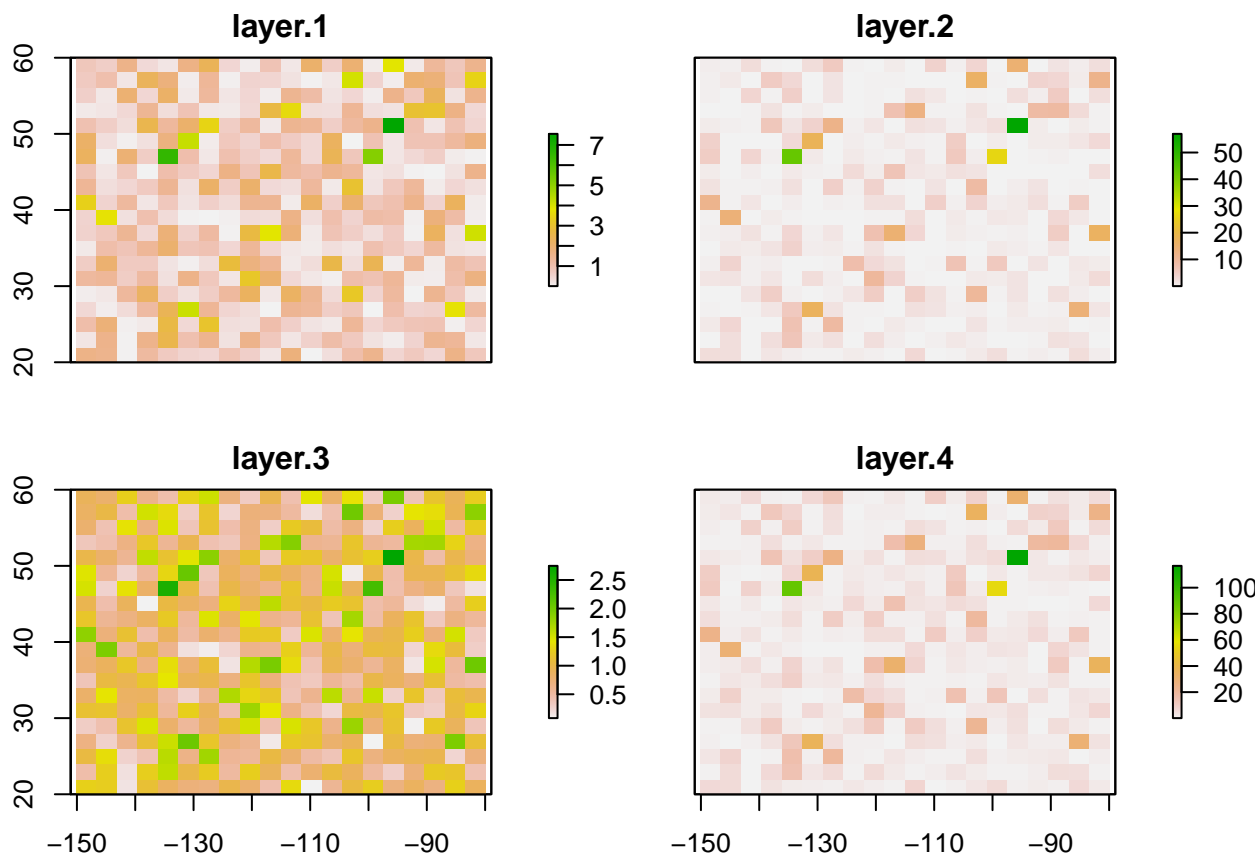
```



```

r2 = r*r
r3 = sqrt(r)
r4 = 2 * r2 + r3
s = stack(r, r2, r3, r4)
plot(s)

```



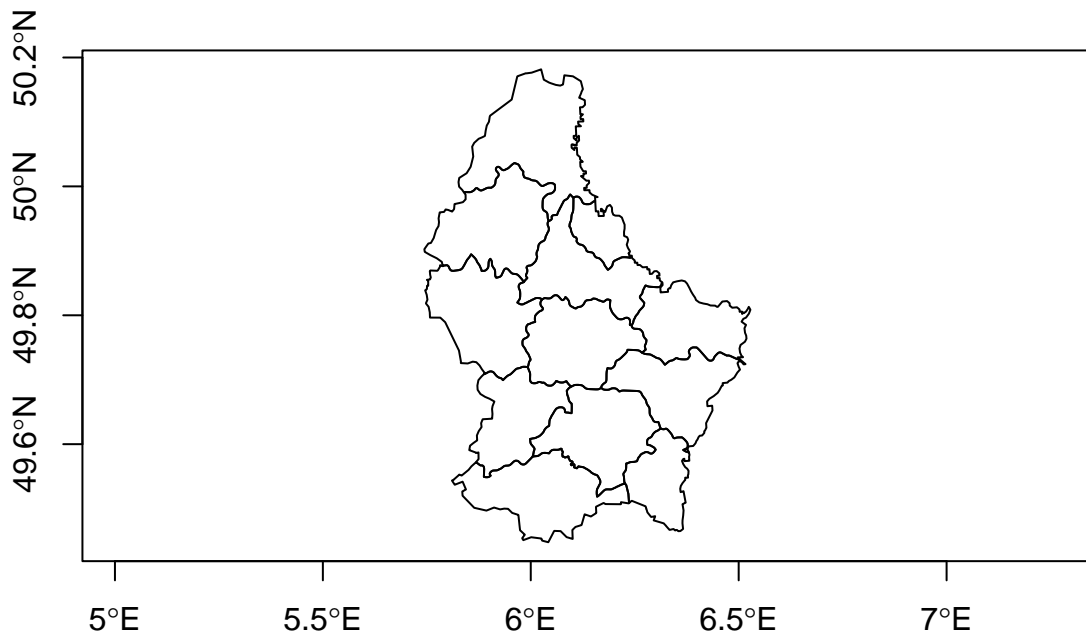
Present data in data frame

```
library(terra)
```

```
## Warning: package 'terra' was built under R version 4.4.2
```

```
## terra 1.7.83
```

```
f = system.file('external/lux.shp', package='raster')
p = shapefile(f)
plot(p, axes=T)
```



```
d = data.frame(p)
```

```
d
```

##	ID_1	NAME_1	ID_2	NAME_2	AREA
## 1	1	Diekirch	1	Clervaux	312
## 2	1	Diekirch	2	Diekirch	218
## 3	1	Diekirch	3	Redange	259
## 4	1	Diekirch	4	Vianden	76
## 5	1	Diekirch	5	Wiltz	263
## 6	2	Grevenmacher	6	Echternach	188
## 7	2	Grevenmacher	7	Remich	129
## 8	2	Grevenmacher	12	Grevenmacher	210
## 9	3	Luxembourg	8	Capellen	185
## 10	3	Luxembourg	9	Esch-sur-Alzette	251
## 11	3	Luxembourg	10	Luxembourg	237
## 12	3	Luxembourg	11	Mersch	233

```
showDefault(p)
```

```
## An object of class "SpatialPolygonsDataFrame"
## Slot "data":
##   ID_1   NAME_1 ID_2   NAME_2 AREA
## 1    1    Diekirch  1    Clervaux 312
## 2    1    Diekirch  2    Diekirch 218
```

```

## 3      1      Diekirch      3      Redange 259
## 4      1      Diekirch      4      Vianden  76
## 5      1      Diekirch      5           Wiltz 263
## 6      2 Grevenmacher      6      Echternach 188
## 7      2 Grevenmacher      7           Remich 129
## 8      2 Grevenmacher     12      Grevenmacher 210
## 9      3      Luxembourg      8      Capellen 185
## 10     3      Luxembourg      9 Esch-sur-Alzette 251
## 11     3      Luxembourg     10      Luxembourg 237
## 12     3      Luxembourg     11           Mersch 233
##
## Slot "polygons":
## [[1]]
## An object of class "Polygons"
## Slot "Polygons":
## [[1]]
## An object of class "Polygon"
## Slot "labpt":
## [1] 6.009082 50.070636
##
## Slot "area":
## [1] 0.03921637
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
## 1 6.026519 50.17767
## 2 6.031361 50.16563
## 3 6.035646 50.16410
## 4 6.042747 50.16157
## 5 6.043894 50.16116
## 6 6.048243 50.16008
## 7 6.058833 50.15779
## 8 6.060411 50.15745
## 9 6.070838 50.15641
## 10 6.077541 50.15807
## 11 6.080800 50.17240
## 12 6.101561 50.17081
## 13 6.107108 50.16858
## 14 6.120430 50.16320
## 15 6.124232 50.15381
## 16 6.125362 50.15102
## 17 6.124943 50.15047
## 18 6.122098 50.14677
## 19 6.121018 50.14440
## 20 6.116489 50.13781
## 21 6.116355 50.13762
## 22 6.122279 50.13591
## 23 6.127972 50.13428

```

24 6.129925 50.13377
25 6.130520 50.12660
26 6.124599 50.12284
27 6.118379 50.12276
28 6.119270 50.11173
29 6.125499 50.11181
30 6.119559 50.10805
31 6.119860 50.10437
32 6.126100 50.10445
33 6.126390 50.10077
34 6.113909 50.10061
35 6.114210 50.09693
36 6.120749 50.09333
37 6.108259 50.09317
38 6.109429 50.07846
39 6.103168 50.07839
40 6.103457 50.07470
41 6.110010 50.07111
42 6.109720 50.07478
43 6.115680 50.07854
44 6.116271 50.07119
45 6.110311 50.06743
46 6.110498 50.06504
47 6.110600 50.06375
48 6.104339 50.06368
49 6.104257 50.06472
50 6.099645 50.06538
51 6.098003 50.06456
52 6.098370 50.05991
53 6.104920 50.05632
54 6.104629 50.05999
55 6.110890 50.06007
56 6.111556 50.05172
57 6.111769 50.04904
58 6.118320 50.04544
59 6.118609 50.04177
60 6.125159 50.03817
61 6.118908 50.03809
62 6.119489 50.03073
63 6.126340 50.02346
64 6.132589 50.02354
65 6.132890 50.01986
66 6.126629 50.01978
67 6.126919 50.01610
68 6.120660 50.01602
69 6.133770 50.00883
70 6.140031 50.00891
71 6.140320 50.00523
72 6.134349 50.00147
73 6.134647 49.99779
74 6.128380 49.99772
75 6.128678 49.99404
76 6.141200 49.99420
77 6.141489 49.99052

78 6.148049 49.98692
79 6.160850 49.98341
80 6.154601 49.98332
81 6.155072 49.97744
82 6.154140 49.97733
83 6.152314 49.97695
84 6.149750 49.97596
85 6.144959 49.97356
86 6.143180 49.97294
87 6.141286 49.97258
88 6.139316 49.97241
89 6.134291 49.97238
90 6.131309 49.97256
91 6.129381 49.97283
92 6.127553 49.97331
93 6.126048 49.97403
94 6.125395 49.97445
95 6.124285 49.97540
96 6.123444 49.97648
97 6.121974 49.97880
98 6.120296 49.98049
99 6.118977 49.98154
100 6.117520 49.98251
101 6.115886 49.98333
102 6.114977 49.98366
103 6.114041 49.98390
104 6.112107 49.98416
105 6.109166 49.98415
106 6.108197 49.98405
107 6.106437 49.98369
108 6.102471 49.98241
109 6.099638 49.98413
110 6.094872 49.98745
111 6.093073 49.98602
112 6.091992 49.98504
113 6.089803 49.98233
114 6.088713 49.98140
115 6.086698 49.98026
116 6.085132 49.97970
117 6.082650 49.97898
118 6.081188 49.97834
119 6.079884 49.97753
120 6.078795 49.97659
121 6.077146 49.97436
122 6.074422 49.97127
123 6.072911 49.96894
124 6.070158 49.96585
125 6.068609 49.96354
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##
##
## [[3]]
## An object of class "Polygons"
## Slot "Polygons":
## [[1]]
## An object of class "Polygon"
## Slot "labpt":
## [1] 5.886502 49.800138
##
## Slot "area":

```

```

## [1] 0.03240219
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
## 774  5.881378 49.87015
## 775  5.881672 49.86887
## 776  5.886637 49.86884
## 777  5.888580 49.86902
## 778  5.889531 49.86919
## 779  5.891358 49.86978
## 780  5.893010 49.87056
## 781  5.894516 49.87146
## 782  5.895867 49.87247
## 783  5.896998 49.87360
## 784  5.897441 49.87421
## 785  5.898018 49.87557
## 786  5.898284 49.87697
## 787  5.898660 49.88197
## 788  5.899240 49.88403
## 789  5.899600 49.88468
## 790  5.900492 49.88575
## 791  5.902771 49.88764
## 792  5.904899 49.88562
## 793  5.905711 49.88452
## 794  5.906010 49.88390
## 795  5.906375 49.88261
## 796  5.906878 49.87868
## 797  5.907245 49.87740
## 798  5.907545 49.87678
## 799  5.907955 49.87617
## 800  5.908996 49.87502
## 801  5.912557 49.87175
## 802  5.913463 49.87054
## 803  5.913975 49.86927
## 804  5.914212 49.86796
## 805  5.914371 49.86328
## 806  5.914677 49.86133
## 807  5.914894 49.86071
## 808  5.915545 49.85961
## 809  5.916890 49.85825
## 810  5.920084 49.85863
## 811  5.924633 49.85954
## 812  5.926035 49.85992
## 813  5.927547 49.86057
## 814  5.928851 49.86140
## 815  5.929905 49.86237
## 816  5.931422 49.86465
## 817  5.933575 49.86726

```

818 5.935050 49.86963
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820 5.937012 49.87147
821 5.938443 49.87217
822 5.939275 49.87241
823 5.940027 49.87253
824 5.941555 49.87256
825 5.943053 49.87231
826 5.943873 49.87205
827 5.945336 49.87133
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829 5.951830 49.86671
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831 5.954742 49.86513
832 5.956410 49.86462
833 5.958159 49.86433
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872 5.998350 49.82226
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903 6.013746 49.80183
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1019 5.749579 49.81700
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1032 5.753332 49.85527
1033 5.755500 49.85546

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## 1047 5.781986 49.87769
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## 1049 5.786361 49.87724
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## 1070 5.863834 49.89006
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## 1073 5.869220 49.88551
## 1074 5.870331 49.88374
## 1075 5.871163 49.88263
## 1076 5.872744 49.88110
## 1077 5.875642 49.87862
## 1078 5.877116 49.87704
## 1079 5.878558 49.87468
## 1080 5.880197 49.87252
## 1081 5.880909 49.87140
## 1082 5.881378 49.87015
##
##
##
## Slot "plotOrder":
## [1] 1

```

```

##
## Slot "labpt":
## [1] 5.886502 49.800138
##
## Slot "ID":
## [1] "3"
##
## Slot "area":
## [1] 0.03240219
##
##
## [[4]]
## An object of class "Polygons"
## Slot "Polygons":
## [[1]]
## An object of class "Polygon"
## Slot "labpt":
## [1] 6.165081 49.928861
##
## Slot "area":
## [1] 0.009541371
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
## 1083 6.131309 49.97256
## 1084 6.134291 49.97238
## 1085 6.139316 49.97241
## 1086 6.141286 49.97258
## 1087 6.143180 49.97294
## 1088 6.144959 49.97356
## 1089 6.149750 49.97596
## 1090 6.152314 49.97695
## 1091 6.154140 49.97733
## 1092 6.155072 49.97744
## 1093 6.155387 49.97350
## 1094 6.156370 49.96126
## 1095 6.162619 49.96134
## 1096 6.163209 49.95398
## 1097 6.175720 49.95414
## 1098 6.175129 49.96150
## 1099 6.168880 49.96142
## 1100 6.168579 49.96509
## 1101 6.170826 49.96512
## 1102 6.172098 49.96364
## 1103 6.178999 49.96033
## 1104 6.181153 49.96424
## 1105 6.183731 49.96893
## 1106 6.190536 49.97124

```

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1111 6.208914 49.95456
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1113 6.219171 49.95164
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1115 6.225733 49.94054
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1117 6.224320 49.92950
1118 6.224450 49.92308
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1122 6.232714 49.91327
1123 6.230765 49.90956
1124 6.233480 49.90480
1125 6.238765 49.89900
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1128 6.236600 49.89605
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1183 6.129982 49.90563
1184 6.128717 49.90658
1185 6.127363 49.90746
1186 6.125895 49.90824
1187 6.124274 49.90887
1188 6.122633 49.90924
1189 6.118436 49.90981
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1192 6.115191 49.91079
1193 6.113747 49.91157
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1196 6.110501 49.91435
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1209 6.101310 49.92408
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1211 6.097162 49.93093
1212 6.096514 49.93349
1213 6.095967 49.93473
1214 6.095138 49.93583

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## 1215 6.092986 49.93785
## 1216 6.093430 49.94090
## 1217 6.093868 49.94236
## 1218 6.094599 49.94373
## 1219 6.096396 49.94631
## 1220 6.096970 49.94774
## 1221 6.097306 49.94923
## 1222 6.097907 49.95381
## 1223 6.098499 49.95602
## 1224 6.099239 49.95738
## 1225 6.101066 49.95995
## 1226 6.101840 49.96207
## 1227 6.102259 49.96506
## 1228 6.102476 49.96965
## 1229 6.102660 49.97812
## 1230 6.102471 49.98241
## 1231 6.106437 49.98369
## 1232 6.108197 49.98405
## 1233 6.109166 49.98415
## 1234 6.112107 49.98416
## 1235 6.114041 49.98390
## 1236 6.114977 49.98366
## 1237 6.115886 49.98333
## 1238 6.117520 49.98251
## 1239 6.118977 49.98154
## 1240 6.120296 49.98049
## 1241 6.121974 49.97880
## 1242 6.123444 49.97648
## 1243 6.124285 49.97540
## 1244 6.125395 49.97445
## 1245 6.126048 49.97403
## 1246 6.127553 49.97331
## 1247 6.129381 49.97283
## 1248 6.131309 49.97256
##
##
##
## Slot "plotOrder":
## [1] 1
##
## Slot "labpt":
## [1] 6.165081 49.928861
##
## Slot "ID":
## [1] "4"
##
## Slot "area":
## [1] 0.009541371
##
##
## [[5]]
## An object of class "Polygons"
## Slot "Polygons":
## [[1]]

```

```

## An object of class "Polygon"
## Slot "labpt":
## [1] 5.914545 49.938918
##
## Slot "area":
## [1] 0.03295997
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
## 1249 5.977929 50.02602
## 1250 5.982312 50.02295
## 1251 5.981743 50.02077
## 1252 5.981830 50.01882
## 1253 5.982258 50.01762
## 1254 5.984316 50.01416
## 1255 5.989406 50.01279
## 1256 5.991280 50.01244
## 1257 5.995080 50.01188
## 1258 5.996910 50.01148
## 1259 6.000885 50.01009
## 1260 6.002627 50.00965
## 1261 6.004528 50.00937
## 1262 6.010383 50.00887
## 1263 6.012285 50.00854
## 1264 6.013202 50.00830
## 1265 6.014892 50.00761
## 1266 6.016419 50.00676
## 1267 6.021967 50.00285
## 1268 6.023400 50.00195
## 1269 6.024971 50.00121
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## 1271 6.026772 50.00075
## 1272 6.028662 50.00068
## 1273 6.030437 50.00094
## 1274 6.034289 50.00223
## 1275 6.037730 50.00321
## 1276 6.040488 50.00438
## 1277 6.045314 50.00506
## 1278 6.047326 50.00516
## 1279 6.050323 50.00507
## 1280 6.052269 50.00484
## 1281 6.054124 50.00443
## 1282 6.055623 50.00386
## 1283 6.057764 50.00282
## 1284 6.058357 49.99946
## 1285 6.058390 49.99742
## 1286 6.058220 49.99609
## 1287 6.057808 49.99479

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1299 6.034355 49.98453
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1302 6.029792 49.98068
1303 6.029433 49.98003
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1577 5.916834 50.02470
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1581 5.916735 50.02837
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1589 5.930055 50.02644
1590 5.931502 50.02573
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1595 5.937686 50.02563
1596 5.940761 50.02668
1597 5.943525 50.02743
1598 5.945063 50.02798
1599 5.947434 50.02916
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1603 5.961040 50.03632
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1605 5.968068 50.03463
1606 5.968933 50.03435
1607 5.970414 50.03364
1608 5.971668 50.03277
1609 5.972670 50.03177
1610 5.974165 50.02949
1611 5.975572 50.02795

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## 1612 5.977929 50.02602
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## Slot "plotOrder":
## [1] 1
##
## Slot "labpt":
## [1] 5.914545 49.938918
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## Slot "ID":
## [1] "5"
##
## Slot "area":
## [1] 0.03295997
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##
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## An object of class "Polygon"
## Slot "labpt":
## [1] 6.378449 49.785109
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## Slot "area":
## [1] 0.02350635
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
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## 1614 6.388600 49.83368
## 1615 6.390184 49.83195
## 1616 6.395162 49.82735
## 1617 6.397452 49.82360
## 1618 6.405219 49.81997
## 1619 6.415373 49.81821
## 1620 6.424975 49.81713
## 1621 6.432136 49.81520
## 1622 6.443452 49.81495
## 1623 6.447955 49.81307
## 1624 6.450050 49.81320
## 1625 6.452540 49.81510
## 1626 6.460710 49.82133
## 1627 6.472089 49.82205
## 1628 6.478120 49.81872
## 1629 6.478250 49.81740
## 1630 6.478480 49.81502

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## 1847 6.311520 49.84294
## 1848 6.312281 49.83550
## 1849 6.330179 49.83639
## 1850 6.329789 49.84009
## 1851 6.332004 49.84168
## 1852 6.333697 49.84174
## 1853 6.335414 49.84180
## 1854 6.337848 49.84666
## 1855 6.339241 49.84801
## 1856 6.342431 49.85111
## 1857 6.351377 49.85266
## 1858 6.362998 49.85403
## 1859 6.370845 49.85269
## 1860 6.375780 49.84923
## 1861 6.381573 49.84235
## 1862 6.385532 49.83703
##
##
##
## Slot "plotOrder":
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## Slot "labpt":
## [1] 6.378449 49.785109
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## Slot "ID":
## [1] "6"
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## Slot "area":
## [1] 0.02350635
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##
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## [1] 6.311601 49.545695
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## Slot "area":
## [1] 0.016026
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
## 1863 6.316665 49.62337
## 1864 6.318350 49.62316
## 1865 6.320131 49.62317

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1866 6.320980 49.62326
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1946 6.366289 49.46839
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1948 6.359714 49.46516
1949 6.354821 49.46498
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1951 6.347110 49.46603
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1953 6.334386 49.46699
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1956 6.324391 49.47377
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1958 6.324293 49.47385
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1961 6.300350 49.48082
1962 6.297490 49.48136
1963 6.295625 49.48172
1964 6.296607 49.48349
1965 6.299231 49.48821
1966 6.289472 49.48697
1967 6.280569 49.49416
1968 6.279777 49.49584
1969 6.278474 49.49861
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1971 6.277751 49.50014
1972 6.276154 49.50354
1973 6.243451 49.51199

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1976 6.234734 49.52286
1977 6.229656 49.53640
1978 6.225736 49.53991
1979 6.224969 49.54195
1980 6.224690 49.54342
1981 6.224127 49.54921
1982 6.223753 49.55052
1983 6.222847 49.55256
1984 6.222746 49.55359
1985 6.222929 49.55415
1986 6.223691 49.55519
1987 6.227653 49.55867
1988 6.228115 49.55925
1989 6.228784 49.56056
1990 6.229163 49.56195
1991 6.229439 49.56411
1992 6.229596 49.56999
1993 6.233290 49.57053
1994 6.237329 49.57169
1995 6.239093 49.57205
1996 6.241001 49.57224
1997 6.248813 49.57257
1998 6.255628 49.57359
1999 6.256813 49.57601
2000 6.258920 49.57907
2001 6.259897 49.57989
2002 6.261506 49.58091
2003 6.263268 49.58271
2004 6.264348 49.58359
2005 6.265640 49.58438
2006 6.267111 49.58504
2007 6.270509 49.58602
2008 6.274468 49.58731
2009 6.276268 49.58765
2010 6.278193 49.58775
2011 6.280115 49.58765
2012 6.281970 49.58738
2013 6.283626 49.58690
2014 6.285805 49.58604
2015 6.287336 49.58555
2016 6.289138 49.58532
2017 6.290998 49.58545
2018 6.291826 49.58564
2019 6.293354 49.58620
2020 6.295424 49.58735
2021 6.297971 49.58923
2022 6.300440 49.59150
2023 6.298118 49.59360
2024 6.296133 49.59486
2025 6.294579 49.59554
2026 6.292084 49.59639
2027 6.289014 49.59760

```

## 2028 6.287377 49.59811
## 2029 6.285508 49.59846
## 2030 6.283574 49.59863
## 2031 6.280721 49.59872
## 2032 6.280143 49.60043
## 2033 6.279864 49.60168
## 2034 6.279746 49.60303
## 2035 6.279808 49.60437
## 2036 6.280098 49.60567
## 2037 6.280363 49.60630
## 2038 6.280738 49.60691
## 2039 6.281749 49.60791
## 2040 6.282362 49.60834
## 2041 6.283734 49.60907
## 2042 6.285294 49.60962
## 2043 6.287743 49.61032
## 2044 6.288479 49.61061
## 2045 6.289848 49.61133
## 2046 6.291037 49.61219
## 2047 6.291541 49.61267
## 2048 6.293240 49.61486
## 2049 6.294242 49.61586
## 2050 6.296057 49.61725
## 2051 6.298102 49.61852
## 2052 6.299570 49.61926
## 2053 6.301128 49.61988
## 2054 6.304585 49.62084
## 2055 6.306120 49.62141
## 2056 6.310536 49.62347
## 2057 6.312236 49.62416
## 2058 6.316665 49.62337
##
##
##
## Slot "plotOrder":
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##
## Slot "labpt":
## [1] 6.311601 49.545695
##
## Slot "ID":
## [1] "7"
##
## Slot "area":
## [1] 0.016026
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##
## [[8]]
## An object of class "Polygons"
## Slot "Polygons":
## [[1]]
## An object of class "Polygon"
## Slot "labpt":
## [1] 6.346395 49.687418

```



```

##
## Slot "area":
## [1] 0.02620982
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
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## 2060 6.426570 49.73082
## 2061 6.427332 49.73046
## 2062 6.428151 49.73015
## 2063 6.429815 49.72976
## 2064 6.430670 49.72964
## 2065 6.432395 49.72955
## 2066 6.434113 49.72963
## 2067 6.435781 49.72993
## 2068 6.437345 49.73056
## 2069 6.438025 49.73095
## 2070 6.439194 49.73186
## 2071 6.440011 49.73281
## 2072 6.440869 49.73417
## 2073 6.441630 49.73515
## 2074 6.442689 49.73615
## 2075 6.443896 49.73711
## 2076 6.446520 49.73896
## 2077 6.449276 49.74068
## 2078 6.451485 49.74177
## 2079 6.453137 49.74226
## 2080 6.453892 49.74237
## 2081 6.455417 49.74240
## 2082 6.456916 49.74221
## 2083 6.457753 49.74200
## 2084 6.464350 49.73973
## 2085 6.471368 49.73750
## 2086 6.475485 49.73763
## 2087 6.478621 49.73719
## 2088 6.494325 49.73257
## 2089 6.497560 49.73191
## 2090 6.501184 49.73172
## 2091 6.502380 49.73188
## 2092 6.516485 49.72418
## 2093 6.512013 49.72378
## 2094 6.511858 49.72390
## 2095 6.507083 49.72771
## 2096 6.500683 49.72897
## 2097 6.498479 49.72688
## 2098 6.497116 49.72558
## 2099 6.499993 49.72012
## 2100 6.501064 49.71864

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2106 6.476208 49.69788
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2108 6.467570 49.69515
2109 6.461548 49.69477
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2117 6.442267 49.67585
2118 6.440990 49.67519
2119 6.440500 49.67482
2120 6.439434 49.67439
2121 6.429440 49.67038
2122 6.424100 49.66633
2123 6.424829 49.65893
2124 6.436261 49.65965
2125 6.436368 49.65858
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2127 6.421670 49.63266
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2129 6.422409 49.62524
2130 6.421841 49.62481
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2132 6.417171 49.61997
2133 6.417420 49.61749
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2147 6.375193 49.58806
2148 6.373098 49.58854
2149 6.370787 49.58933
2150 6.366523 49.59103
2151 6.370027 49.59194
2152 6.373841 49.59311
2153 6.375309 49.59365
2154 6.375960 49.59404

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2159 6.377429 49.59946
2160 6.377074 49.60077
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2162 6.375274 49.60315
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2164 6.371259 49.60622
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2166 6.366712 49.60901
2167 6.363362 49.61066
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2173 6.346106 49.60919
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2201 6.298713 49.63458
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2203 6.295623 49.63591
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2205 6.293612 49.63792
2206 6.292144 49.64018
2207 6.289577 49.64277
2208 6.287457 49.64478

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2217 6.279142 49.66266
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2220 6.274529 49.67044
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2222 6.268538 49.67560
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2233 6.218142 49.68288
2234 6.213029 49.68165
2235 6.208783 49.68438
2236 6.207196 49.68527
2237 6.205440 49.68599
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2242 6.195755 49.68660
2243 6.193887 49.68629
2244 6.189885 49.68505
2245 6.188135 49.68465
2246 6.185239 49.68437
2247 6.181246 49.68432
2248 6.177268 49.68455
2249 6.174397 49.68502
2250 6.173491 49.68528
2251 6.171922 49.68592
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2253 6.169600 49.68877
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2259 6.180346 49.69628
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2297 6.275429 49.73996
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2301 6.290008 49.73849
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2314 6.330997 49.72776
2315 6.333520 49.72885
2316 6.335334 49.72932

```

## 2317 6.339985 49.72994
## 2318 6.341784 49.73030
## 2319 6.343495 49.73089
## 2320 6.348123 49.73301
## 2321 6.349721 49.73344
## 2322 6.350568 49.73352
## 2323 6.351339 49.73348
## 2324 6.352794 49.73317
## 2325 6.354997 49.73254
## 2326 6.356759 49.73219
## 2327 6.358655 49.73196
## 2328 6.361629 49.73173
## 2329 6.365691 49.73156
## 2330 6.369778 49.73153
## 2331 6.372849 49.73165
## 2332 6.376956 49.73200
## 2333 6.381028 49.73528
## 2334 6.381933 49.73627
## 2335 6.382260 49.73681
## 2336 6.382562 49.73804
## 2337 6.382352 49.73925
## 2338 6.380429 49.74232
## 2339 6.380193 49.74354
## 2340 6.380472 49.74479
## 2341 6.380805 49.74536
## 2342 6.381239 49.74588
## 2343 6.382319 49.74686
## 2344 6.383589 49.74775
## 2345 6.384995 49.74855
## 2346 6.386529 49.74925
## 2347 6.388219 49.74978
## 2348 6.390150 49.75007
## 2349 6.392127 49.75016
## 2350 6.398983 49.75002
## 2351 6.402157 49.74825
## 2352 6.405591 49.74598
## 2353 6.414771 49.73930
## 2354 6.423176 49.73302
## 2355 6.425158 49.73164
##
##
##
## Slot "plotOrder":
## [1] 1
##
## Slot "labpt":
## [1] 6.346395 49.687418
##
## Slot "ID":
## [1] "8"
##
## Slot "area":
## [1] 0.02620982
##

```

```

##
## [[9]]
## An object of class "Polygons"
## Slot "Polygons":
## [[1]]
## An object of class "Polygon"
## Slot "labpt":
## [1] 5.963503 49.641589
##
## Slot "area":
## [1] 0.02310772
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
## 2356 5.998312 49.69992
## 2357 5.998632 49.69856
## 2358 5.998956 49.69790
## 2359 5.999366 49.69733
## 2360 6.000454 49.69633
## 2361 6.001845 49.69551
## 2362 6.003561 49.69493
## 2363 6.005455 49.69463
## 2364 6.007399 49.69451
## 2365 6.010342 49.69455
## 2366 6.013215 49.69485
## 2367 6.014944 49.69525
## 2368 6.018064 49.69619
## 2369 6.019788 49.69648
## 2370 6.020710 49.69651
## 2371 6.021638 49.69649
## 2372 6.023353 49.69626
## 2373 6.028385 49.69516
## 2374 6.029469 49.69543
## 2375 6.030759 49.69553
## 2376 6.031482 49.69543
## 2377 6.032184 49.69523
## 2378 6.033527 49.69463
## 2379 6.036830 49.69267
## 2380 6.038293 49.69193
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## 2382 6.040802 49.69118
## 2383 6.042593 49.69092
## 2384 6.045341 49.69075
## 2385 6.047178 49.69075
## 2386 6.048995 49.69088
## 2387 6.050760 49.69119
## 2388 6.051601 49.69145
## 2389 6.053151 49.69210

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2603 5.906943 49.65457
2604 5.908158 49.65912
2605 5.912500 49.66616

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## 2610 5.872259 49.68431
## 2611 5.871624 49.69093
## 2612 5.874096 49.69931
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## 2630 5.946764 49.70700
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## 2638 5.972301 49.71796
## 2639 5.974117 49.71826
## 2640 5.978123 49.71947
## 2641 5.978964 49.71967
## 2642 5.980852 49.71995
## 2643 5.982812 49.72005
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## 2645 5.988688 49.71985
## 2646 5.992929 49.71941
## 2647 5.995628 49.71451
## 2648 5.997559 49.71179
## 2649 5.998139 49.71054
## 2650 5.998439 49.70917
## 2651 5.998536 49.70775
## 2652 5.998257 49.70202
## 2653 5.998312 49.69992
##
##
##
## Slot "plotOrder":
## [1] 1
##

```

```

## Slot "labpt":
## [1] 5.963503 49.641589
##
## Slot "ID":
## [1] "9"
##
## Slot "area":
## [1] 0.02310772
##
##
## [[10]]
## An object of class "Polygons"
## Slot "Polygons":
## [[1]]
## An object of class "Polygon"
## Slot "labpt":
## [1] 6.023816 49.523310
##
## Slot "area":
## [1] 0.03121033
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
## 2654 6.039474 49.44826
## 2655 6.036906 49.44870
## 2656 6.036822 49.44871
## 2657 6.031922 49.44954
## 2658 6.027222 49.45034
## 2659 6.026355 49.45215
## 2660 6.025686 49.45354
## 2661 6.019075 49.45409
## 2662 6.007997 49.45501
## 2663 6.002670 49.45544
## 2664 6.001159 49.45557
## 2665 6.001039 49.45558
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## 2667 5.982054 49.45107
## 2668 5.980053 49.45325
## 2669 5.979316 49.45405
## 2670 5.985664 49.45955
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## 2672 5.975504 49.46565
## 2673 5.974236 49.46642
## 2674 5.973628 49.47001
## 2675 5.972620 49.47595
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## 2677 5.972017 49.47952
## 2678 5.971817 49.48069

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## 3057 6.211611 49.53514
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## 3065 6.235639 49.50807
## 3066 6.217000 49.50999
## 3067 6.216733 49.50682
## 3068 6.179634 49.50706
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## 3085 6.099470 49.45316
## 3086 6.097742 49.45350
## 3087 6.092067 49.45461
## 3088 6.086264 49.45576
## 3089 6.073121 49.46423
## 3090 6.071874 49.46503
## 3091 6.056344 49.46540
## 3092 6.052418 49.46054
## 3093 6.043079 49.44896
## 3094 6.042336 49.44804
## 3095 6.042151 49.44781
## 3096 6.039474 49.44826
##
##
##
## Slot "plotOrder":
## [1] 1
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## Slot "labpt":
## [1] 6.023816 49.523310
##
## Slot "ID":
## [1] "10"
##
## Slot "area":
## [1] 0.03121033

```

```

##
##
## [[1]]
## An object of class "Polygons"
## Slot "Polygons":
## [[1]]
## An object of class "Polygon"
## Slot "labpt":
## [1] 6.167624 49.618151
##
## Slot "area":
## [1] 0.02950228
##
## Slot "hole":
## [1] FALSE
##
## Slot "ringDir":
## [1] 1
##
## Slot "coords":
##           x           y
## 3097 6.155963 49.68505
## 3098 6.159284 49.68504
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## 3101 6.165574 49.68590
## 3102 6.167406 49.68667
## 3103 6.169137 49.68753
## 3104 6.171922 49.68592
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## 3109 6.185239 49.68437
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## 3111 6.189885 49.68505
## 3112 6.193887 49.68629
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## 3126 6.258232 49.68233
## 3127 6.261275 49.68187
## 3128 6.263013 49.68127
## 3129 6.263733 49.68090

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3748 6.264008 49.77750
3749 6.265579 49.77662
3750 6.267643 49.77509
3751 6.269285 49.77337
3752 6.269970 49.77212
3753 6.270985 49.76833
3754 6.271278 49.76772
3755 6.272174 49.76651
3756 6.273339 49.76538
3757 6.274656 49.76431
3758 6.278229 49.76171
3759 6.277864 49.75903
3760 6.277303 49.75710
3761 6.276655 49.75596
3762 6.275109 49.75390
3763 6.274601 49.75275
3764 6.274494 49.75213
3765 6.274490 49.75150
3766 6.274765 49.75032
3767 6.276438 49.74663
3768 6.274911 49.74594
3769 6.272850 49.74482
3770 6.267931 49.74177
3771 6.261834 49.74469
3772 6.259820 49.74529
3773 6.257681 49.74563
3774 6.252104 49.74599
3775 6.232690 49.74645
3776 6.232029 49.74459
3777 6.231256 49.74343
3778 6.229571 49.74188
3779 6.226870 49.74000
3780 6.218154 49.73456
3781 6.214426 49.73243
3782 6.212083 49.73136
3783 6.208741 49.73038
3784 6.207170 49.72981
3785 6.205818 49.72905
3786 6.205223 49.72861
3787 6.204256 49.72762
3788 6.203899 49.72703
3789 6.202659 49.72334
3790 6.201940 49.72217
3791 6.200356 49.72065
3792 6.198415 49.71932
3793 6.196973 49.71854
3794 6.195390 49.71790
3795 6.194528 49.71766
3796 6.192597 49.71739

3797 6.189631 49.71742
3798 6.187962 49.71759
3799 6.184645 49.71807
3800 6.183110 49.71456
3801 6.182539 49.71246
3802 6.182207 49.70880
3803 6.182036 49.70069
3804 6.181730 49.69862
3805 6.181247 49.69736
3806 6.180346 49.69628
3807 6.179755 49.69590
3808 6.175444 49.69393
3809 6.173239 49.69262
3810 6.171889 49.69164
3811 6.170257 49.68998
3812 6.169600 49.68877
3813 6.169137 49.68753
3814 6.167406 49.68667
3815 6.165574 49.68590
3816 6.163569 49.68538
3817 6.161457 49.68513
3818 6.159284 49.68504
3819 6.155963 49.68505
3820 6.142470 49.68541
3821 6.138038 49.68562
3822 6.134824 49.68598
3823 6.133796 49.68619
3824 6.132005 49.68675
3825 6.130529 49.68744
3826 6.125786 49.69015
3827 6.124029 49.69088
3828 6.123077 49.69115
3829 6.121083 49.69151
3830 6.119020 49.69173
3831 6.113731 49.69196
3832 6.108439 49.69195
3833 6.105366 49.69167
3834 6.103538 49.69127
3835 6.099547 49.68994
3836 6.097388 49.68937
3837 6.093895 49.69119
3838 6.091182 49.69296
3839 6.088757 49.69486
3840 6.085760 49.69769
3841 6.084118 49.69739
3842 6.080274 49.69622
3843 6.078523 49.69585
3844 6.076608 49.69566
3845 6.073648 49.69562
3846 6.070677 49.69580
3847 6.067792 49.69626
3848 6.061389 49.69818
3849 6.060259 49.69695
3850 6.059139 49.69598

3851 6.057274 49.69460
3852 6.054587 49.69287
3853 6.053151 49.69210
3854 6.051601 49.69145
3855 6.050760 49.69119
3856 6.048995 49.69088
3857 6.047178 49.69075
3858 6.045341 49.69075
3859 6.042593 49.69092
3860 6.040802 49.69118
3861 6.039097 49.69162
3862 6.038293 49.69193
3863 6.036830 49.69267
3864 6.033527 49.69463
3865 6.032184 49.69523
3866 6.031482 49.69543
3867 6.030759 49.69553
3868 6.029469 49.69543
3869 6.028385 49.69516
3870 6.023353 49.69626
3871 6.021638 49.69649
3872 6.020710 49.69651
3873 6.019788 49.69648
3874 6.018064 49.69619
3875 6.014944 49.69525
3876 6.013215 49.69485
3877 6.010342 49.69455
3878 6.007399 49.69451
3879 6.005455 49.69463
3880 6.003561 49.69493
3881 6.001845 49.69551
3882 6.000454 49.69633
3883 5.999366 49.69733
3884 5.998956 49.69790
3885 5.998632 49.69856
3886 5.998312 49.69992
3887 5.998257 49.70202
3888 5.998536 49.70775
3889 5.998439 49.70917
3890 5.998139 49.71054
3891 5.997559 49.71179
3892 5.995628 49.71451
3893 5.992929 49.71941
3894 5.994591 49.72338
3895 5.995336 49.72593
3896 5.995843 49.72717
3897 5.996205 49.72778
3898 5.997127 49.72882
3899 5.999455 49.73071
3900 5.999100 49.73225
3901 5.998711 49.73325
3902 5.997999 49.73437
3903 5.996361 49.73653
3904 5.995257 49.73843

3905 5.994499 49.73944
3906 5.993468 49.74047
3907 5.990000 49.74345
3908 5.988975 49.74448
3909 5.988218 49.74548
3910 5.987048 49.74736
3911 5.986144 49.74841
3912 5.982200 49.75188
3913 5.980496 49.75350
3914 5.980026 49.75604
3915 5.979951 49.75740
3916 5.980026 49.75874
3917 5.980315 49.76004
3918 5.980578 49.76066
3919 5.981417 49.76180
3920 5.982587 49.76271
3921 5.983986 49.76344
3922 5.985591 49.76398
3923 5.989022 49.76490
3924 5.991454 49.76598
3925 5.993527 49.76729
3926 5.994549 49.76829
3927 5.994872 49.76885
3928 5.995002 49.76946
3929 5.994892 49.77007
3930 5.994594 49.77062
3931 5.993664 49.77164
3932 5.991291 49.77362
3933 5.990184 49.77471
3934 5.989394 49.77593
3935 5.988875 49.77790
3936 5.988815 49.77924
3937 5.988938 49.78057
3938 5.989553 49.78252
3939 5.989923 49.78313
3940 5.990877 49.78419
3941 5.993274 49.78603
3942 5.995162 49.78624
3943 5.997002 49.78655
3944 6.001015 49.78782
3945 6.002719 49.78827
3946 6.007829 49.78928
3947 6.010555 49.78965
3948 6.009947 49.79318
3949 6.009904 49.79591
3950 6.010260 49.79789
3951 6.010848 49.79916
3952 6.011298 49.79976
3953 6.012427 49.80083
3954 6.013746 49.80183
3955 6.015914 49.80323
3956 6.018209 49.80455
3957 6.020590 49.80576
3958 6.022229 49.80643

```

## 3959 6.025550 49.80731
## 3960 6.027038 49.80783
## 3961 6.028222 49.80855
## 3962 6.028676 49.80898
## 3963 6.028999 49.80947
## 3964 6.029145 49.81001
## 3965 6.029069 49.81056
## 3966 6.028819 49.81106
## 3967 6.028001 49.81197
## 3968 6.025270 49.81419
## 3969 6.024268 49.81520
## 3970 6.023543 49.81637
## 3971 6.023210 49.81767
## 3972 6.023213 49.81899
## 3973 6.023334 49.81964
## 3974 6.023852 49.82092
## 3975 6.025105 49.82245
## 3976 6.027617 49.82478
## 3977 6.033381 49.82681
## 3978 6.038065 49.82633
## 3979 6.040915 49.82614
## 3980 6.043824 49.82612
## 3981 6.045720 49.82625
## 3982 6.046644 49.82639
## 3983 6.047542 49.82659
## 3984 6.049155 49.82716
## 3985 6.050623 49.82787
## 3986 6.054133 49.82981
## 3987 6.055653 49.83047
## 3988 6.056483 49.83074
## 3989 6.058368 49.83106
## 3990 6.059337 49.83112
## 3991 6.061288 49.83108
## 3992 6.063210 49.83080
## 3993 6.064136 49.83055
## 3994 6.065808 49.82984
## 3995 6.067982 49.82846
##
##
##
## Slot "plotOrder":
## [1] 1
##
## Slot "labpt":
## [1] 6.113598 49.757444
##
## Slot "ID":
## [1] "12"
##
## Slot "area":
## [1] 0.02911398
##
##
##

```

```
## Slot "plotOrder":
## [1] 1 5 3 10 11 12 2 8 6 9 7 4
##
## Slot "bbox":
##      min      max
## x  5.74414  6.528252
## y 49.44781 50.181622
##
## Slot "proj4string":
## Coordinate Reference System:
## Deprecated Proj.4 representation: +proj=longlat +datum=WGS84 +no_defs
## WKT2 2019 representation:
## GEOGCRS["unknown",
##   DATUM["World Geodetic System 1984",
##     ELLIPSOID["WGS 84",6378137,298.257223563,
##       LENGTHUNIT["metre",1]],
##     ID["EPSG",6326]],
##   PRIMEM["Greenwich",0,
##     ANGLEUNIT["degree",0.0174532925199433],
##     ID["EPSG",8901]],
##   CS[ellipsoidal,2],
##     AXIS["longitude",east,
##       ORDER[1],
##       ANGLEUNIT["degree",0.0174532925199433,
##         ID["EPSG",9122]]],
##     AXIS["latitude",north,
##       ORDER[2],
##       ANGLEUNIT["degree",0.0174532925199433,
##         ID["EPSG",9122]]]]
```

Extract attribute

```
p$NAME_2
```

```
## [1] "Clervaux"      "Diekirch"      "Redange"      "Vianden"
## [5] "Wiltz"         "Echternach"    "Remich"       "Grevenmacher"
## [9] "Capellen"     "Esch-sur-Alzette" "Luxembourg"   "Mersch"
```

```
p$AREA
```

```
## [1] 312 218 259 76 263 188 129 210 185 251 237 233
```

```
p2 = p[, 'NAME_2']
data.frame(p2)
```

```
##      NAME_2
## 1  Clervaux
## 2  Diekirch
## 3   Redange
## 4   Vianden
```



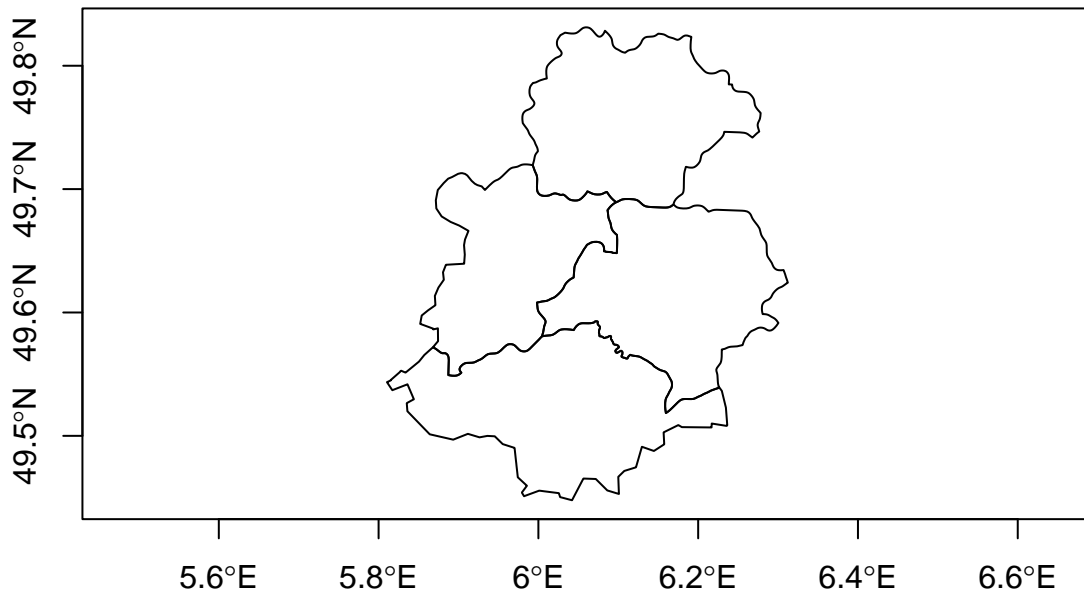
```
## 5          Wiltz
## 6      Echternach
## 7          Remich
## 8      Grevenmacher
## 9          Capellen
## 10 Esch-sur-Alzette
## 11      Luxembourg
## 12          Mersch
```

Add new attribute

```
temp = 10 * rexp(12)
p$Temperature = temp
data.frame(p)
```

##	ID_1	NAME_1	ID_2	NAME_2	AREA	Temperature
## 1	1	Diekirch	1	Clervaux	312	6.8875536
## 2	1	Diekirch	2	Diekirch	218	4.1830143
## 3	1	Diekirch	3	Redange	259	6.9563242
## 4	1	Diekirch	4	Vianden	76	9.9877030
## 5	1	Diekirch	5	Wiltz	263	0.5195073
## 6	2	Grevenmacher	6	Echternach	188	20.2241203
## 7	2	Grevenmacher	7	Remich	129	7.1386454
## 8	2	Grevenmacher	12	Grevenmacher	210	10.1367592
## 9	3	Luxembourg	8	Capellen	185	1.5825189
## 10	3	Luxembourg	9	Esch-sur-Alzette	251	21.0949354
## 11	3	Luxembourg	10	Luxembourg	237	11.3083051
## 12	3	Luxembourg	11	Mersch	233	0.1598931

```
i = which(p$NAME_1 == 'Luxembourg')
g = p[i,]
plot(g, axes = T)
```



Data integration

```
dfr = data.frame(District=p$NAME_1, Canton = p$NAME_2,
                 Precip = round(100*rexp(12),3)) # simulation data

dfr[order(dfr$Canton), ]
```

##	District	Canton	Precip
## 9	Luxembourg	Capellen	213.328
## 1	Diekirch	Clervaux	3.392
## 2	Diekirch	Diekirch	66.249
## 6	Grevenmacher	Echternach	131.342
## 10	Luxembourg	Esch-sur-Alzette	62.770
## 8	Grevenmacher	Grevenmacher	193.160
## 11	Luxembourg	Luxembourg	118.144
## 12	Luxembourg	Mersch	54.988
## 3	Diekirch	Redange	53.725
## 7	Grevenmacher	Remich	264.577
## 4	Diekirch	Vianden	1.153
## 5	Diekirch	Wiltz	83.637

```
data2 = merge(p, dfr, by.x = c('NAME_1', 'NAME_2'), by.y = c('District', 'Canton'))

data.frame(data2)
```

##	NAME_1	NAME_2	ID_1	ID_2	AREA	Temperature	Precip
## 1	Diekirch	Clervaux	1	1	312	6.8875536	3.392
## 2	Diekirch	Diekirch	1	2	218	4.1830143	66.249
## 3	Diekirch	Redange	1	3	259	6.9563242	53.725
## 4	Diekirch	Vianden	1	4	76	9.9877030	1.153
## 5	Diekirch	Wiltz	1	5	263	0.5195073	83.637
## 6	Grevenmacher	Echternach	2	6	188	20.2241203	131.342
## 8	Grevenmacher	Remich	2	7	129	7.1386454	264.577
## 7	Grevenmacher	Grevenmacher	2	12	210	10.1367592	193.160
## 9	Luxembourg	Capellen	3	8	185	1.5825189	213.328
## 10	Luxembourg	Esch-sur-Alzette	3	9	251	21.0949354	62.770
## 11	Luxembourg	Luxembourg	3	10	237	11.3083051	118.144
## 12	Luxembourg	Mersch	3	11	233	0.1598931	54.988

Map manipulation

```

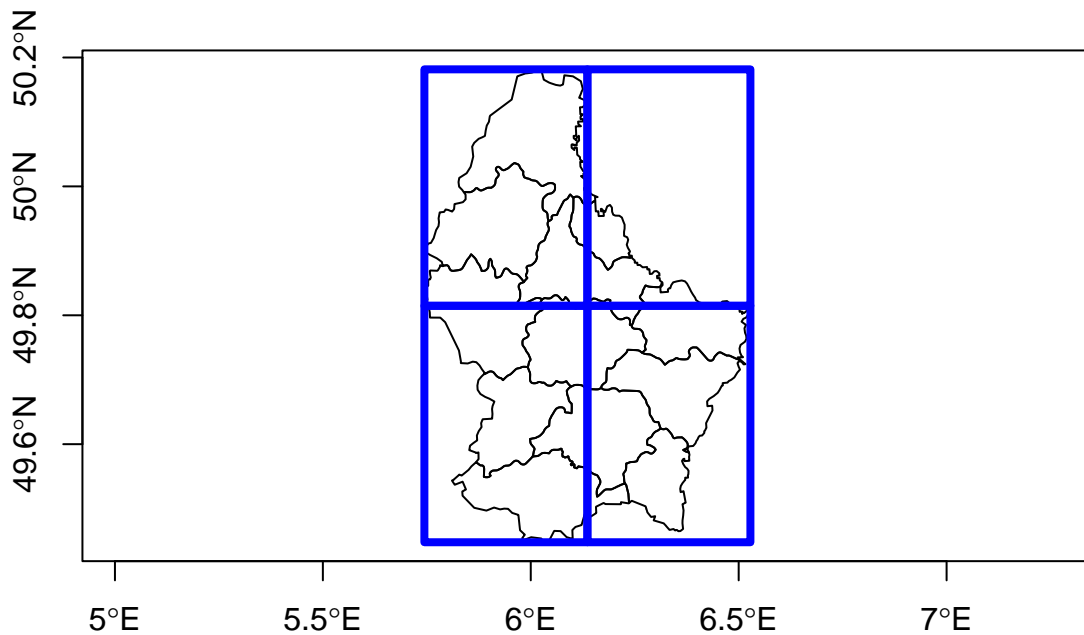
z = raster(p, nrow=2, ncol=2, vals=1:4)

names(z) = 'Zone'

z = as(z, 'SpatialPolygonsDataFrame')

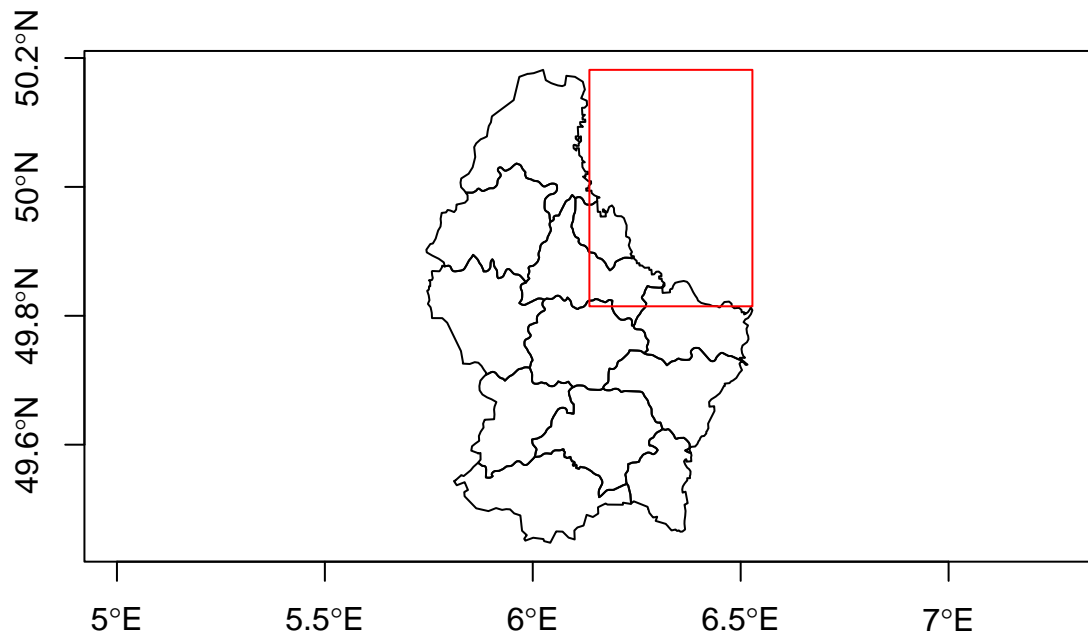
plot(p, axes=T)
plot(z, add = T, border = 'blue', lwd = 4)

```

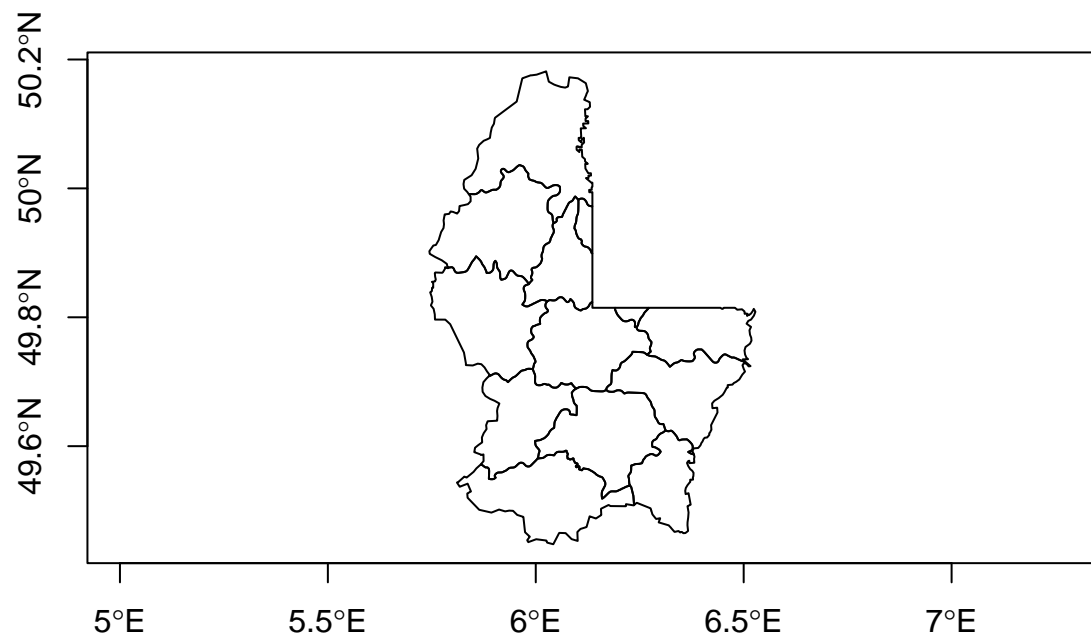


Buang zone tertentu

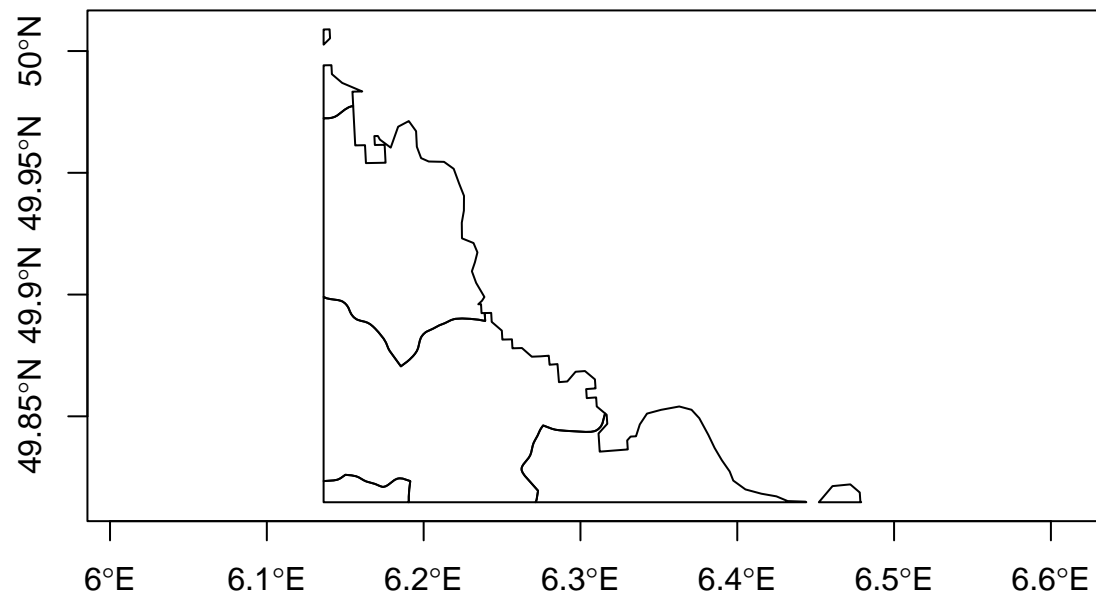
```
z2 = z[2, ]  
plot(p, axes=T)  
plot(z2, add = T, border = 'red')
```



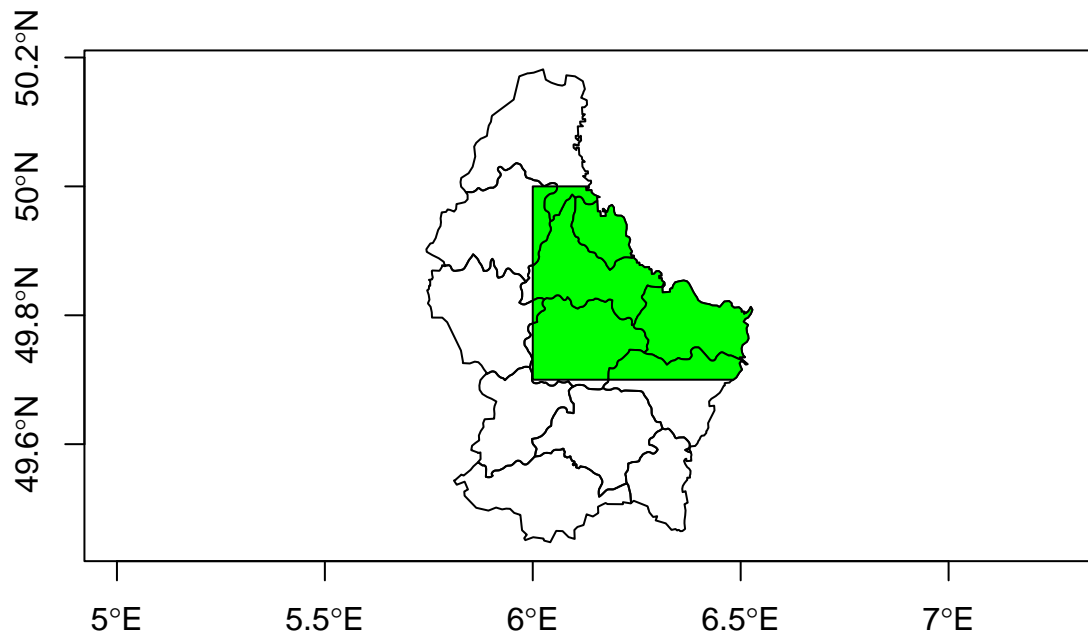
```
e = erase(p, z2)  
plot(e, axes = T)
```



```
e = intersect(p, z2)
plot(e, axes = T)
```



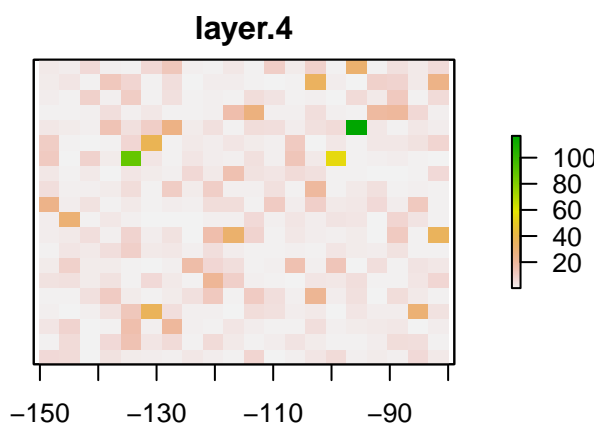
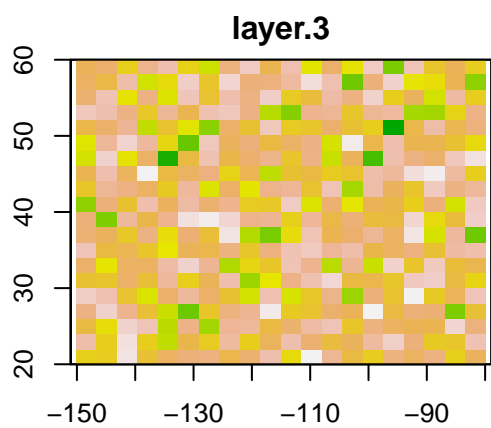
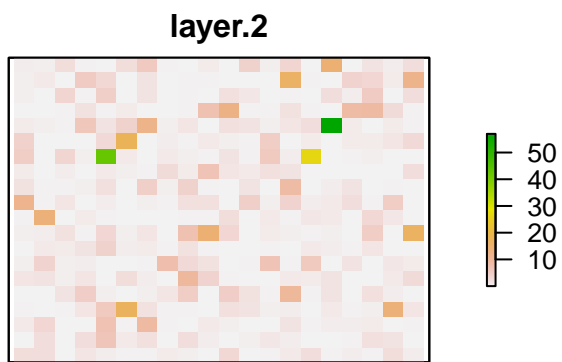
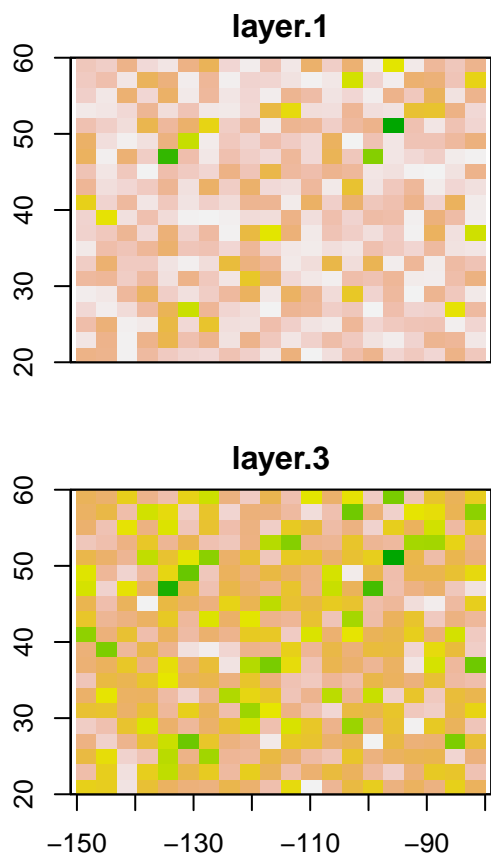
```
e3 = extent(6,6.8,49.7,50)
pe = crop(p, e3)
plot(p, axes=T)
plot(pe, axes = T, add = T, col= 'green')
```



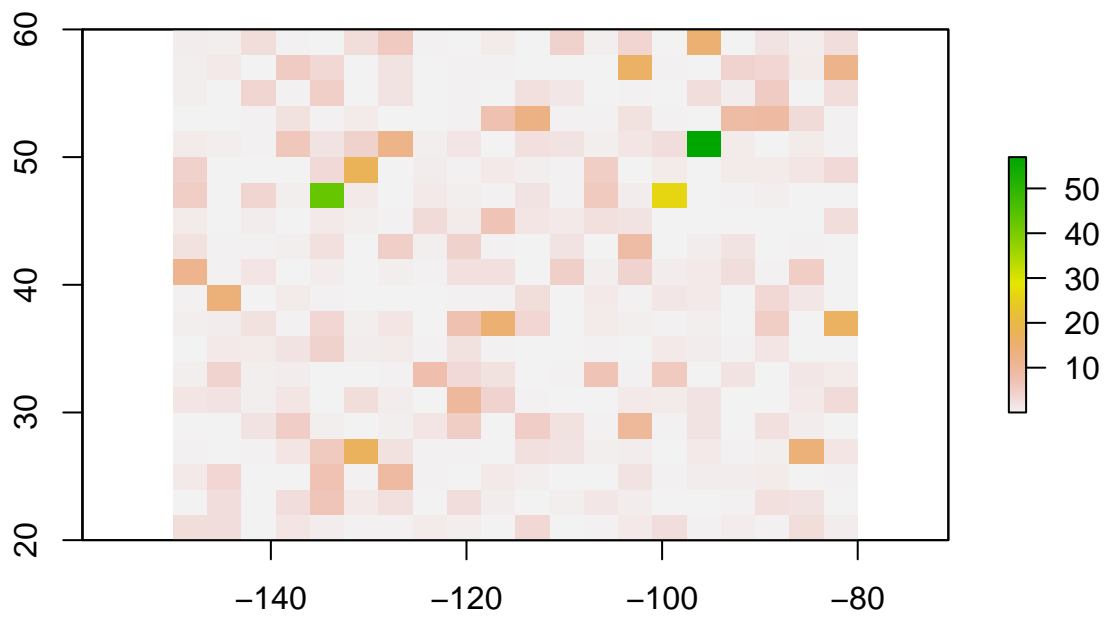
Data manipulation for spatial raster

Extracts a single RasterLayer object from a RasterBrick or RasterStack object.

```
plot(s)
```

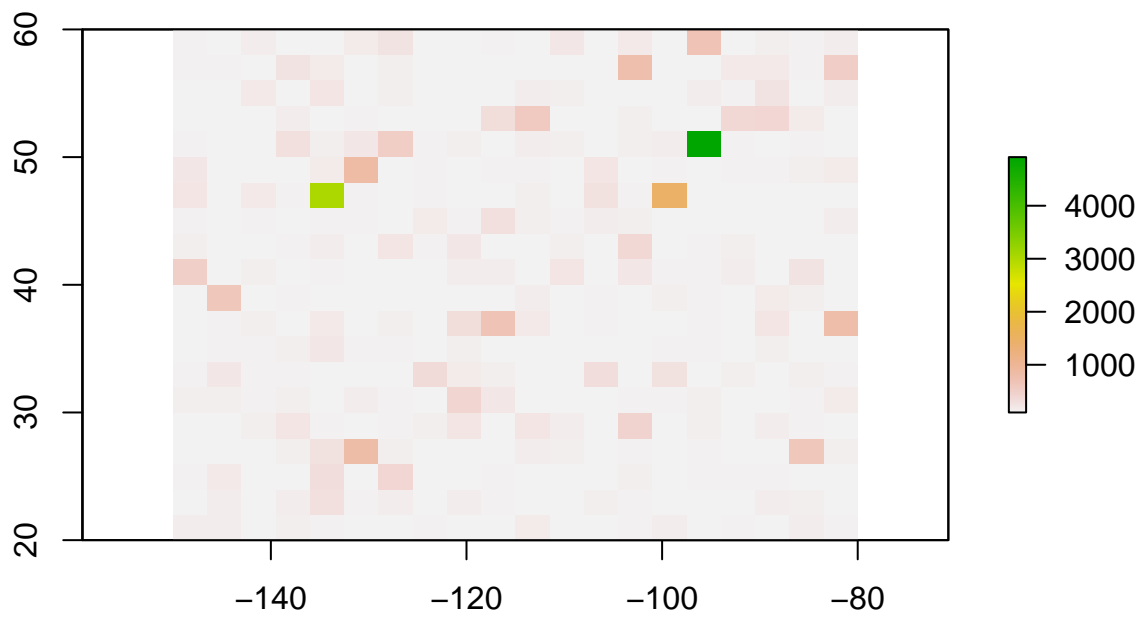


```
r5 = raster(s, layer = 2)
plot(r5)
```

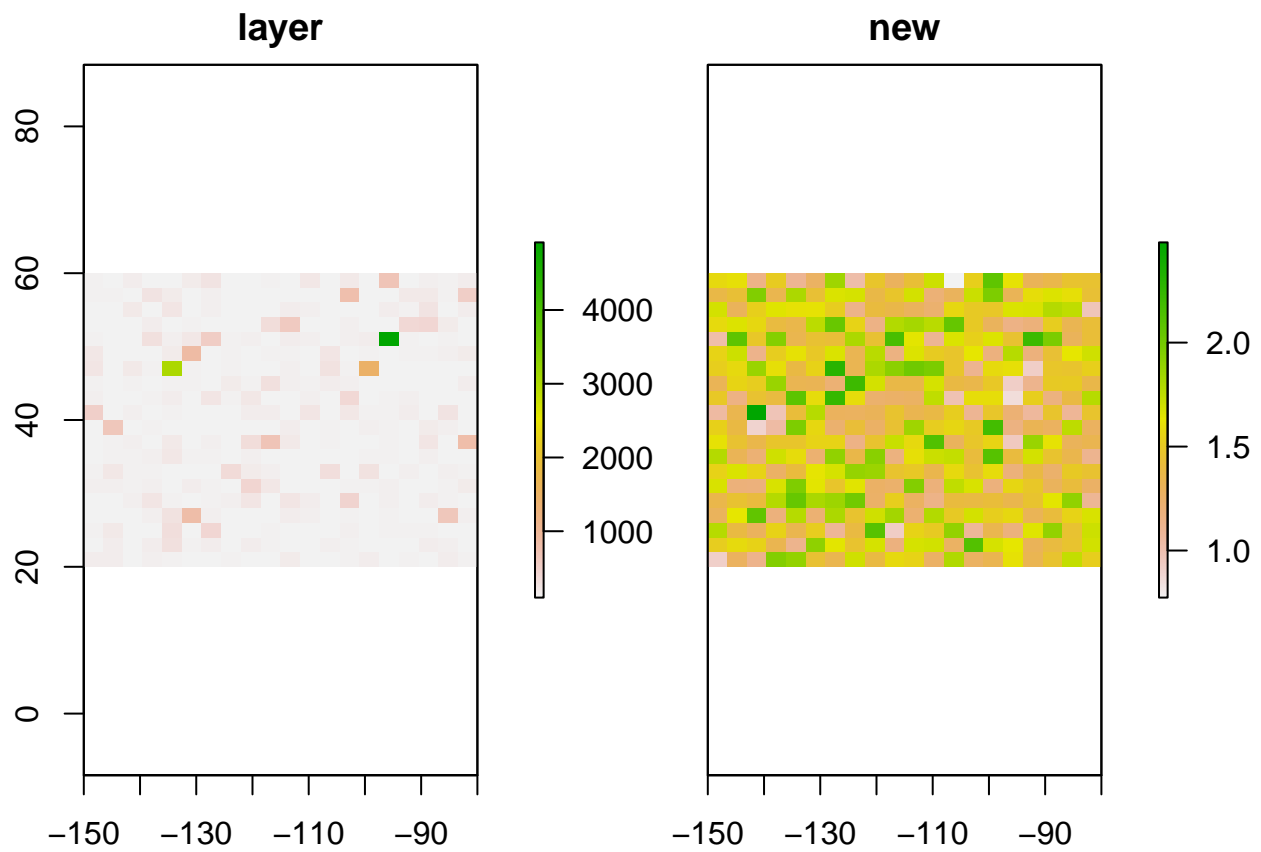
Algebra in raster data

```
r6 = r2 + 10  
r7 = r6 ^ 2  
r8 = r * r2 + r7  
plot(r8)
```



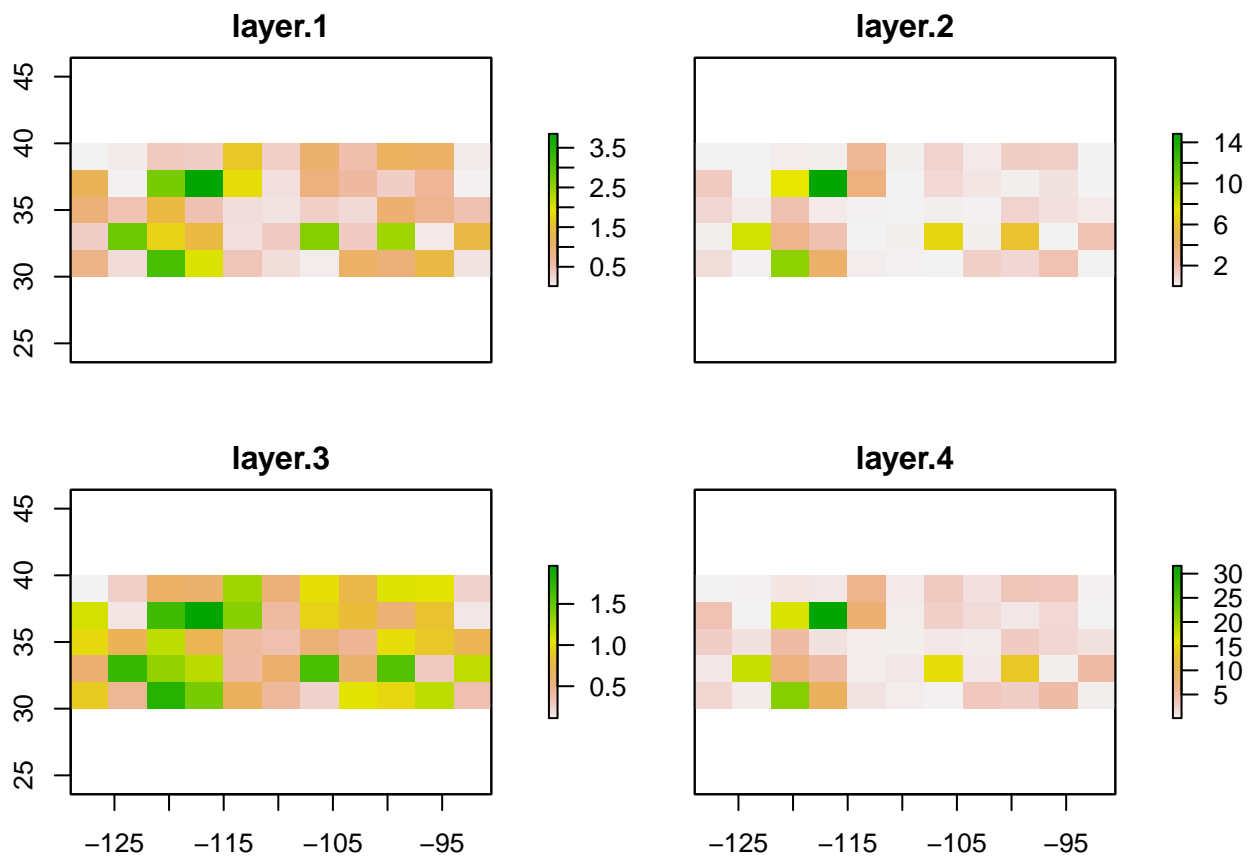
Add new values in the cell.

```
pi = rgamma(400,30,20)
r8$new = pi
plot(r8)
```

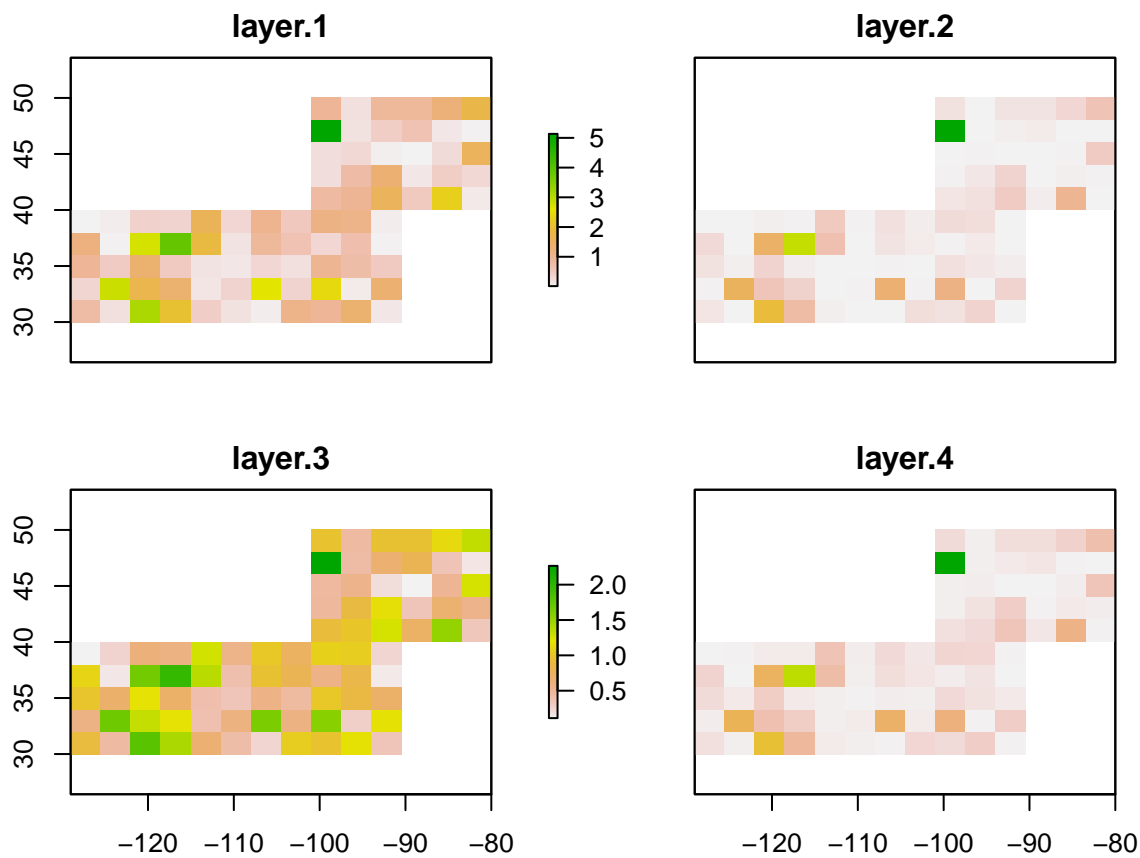


Crop and merge raster data

```
l2 = crop(s, extent(-130, -90, 30,40))  
plot(l2)
```



```
l3 = crop(s, extent(-100, -80, 40, 50))
m = merge(l2, l3)
plot(m)
```



Descriptive functions.

mean

```
cellStats(s, mean)
```

```
## layer.1 layer.2 layer.3 layer.4
## 1.0229962 2.0290029 0.9035182 4.9615240
```

standard deviation

```
cellStats(s, sd)
```

```
## layer.1 layer.2 layer.3 layer.4
## 0.9924434 4.6798729 0.4551582 9.6959031
```

can try for other statistical measure such as median, range and so on