Spatial Data and Cartography (Part 2)

Lecture 18

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Plotting

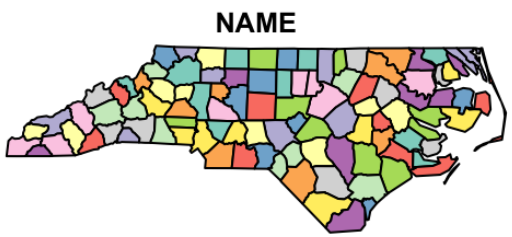
Example Data - NC SIDS

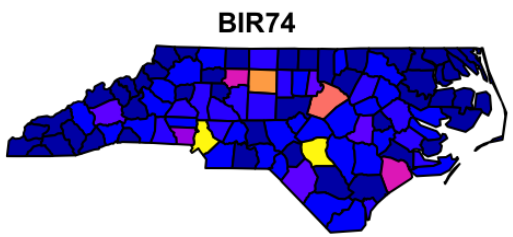
```
( nc = read_sf(system.file("shape/nc.shp", package="sf"), quiet = TRUE)
    select(-(AREA:CNTY_ID), -(FIPS:CRESS_ID)))
```

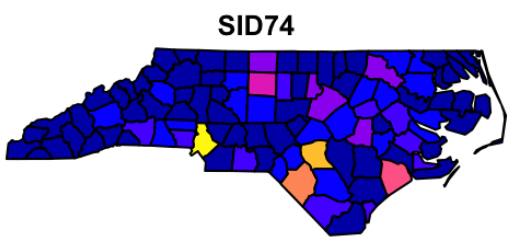
```
Simple feature collection with 100 features and 7 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax:
36.58965
Geodetic CRS:  NAD27
# A tibble: 100 × 8
   NAME        BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79
   <chr>       <dbl> <dbl>   <dbl> <dbl> <dbl>   <dbl>
 1 Ashe         1091     1      10  1364     0      19
 2 Alleghany     487     0      10   542     3      12
 3 Surry        3188     5     208  3616     6     260
```

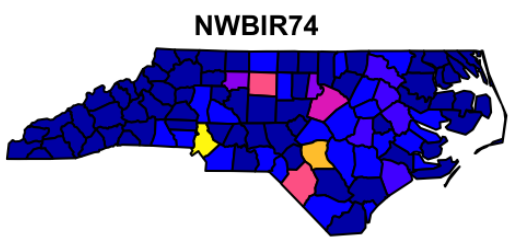
Base Plots

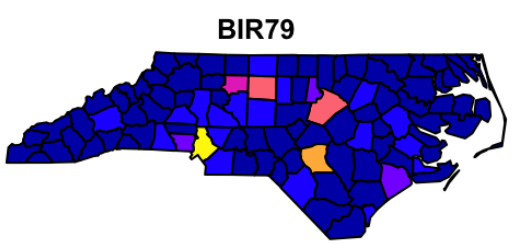
```
1  plot(nc)
```

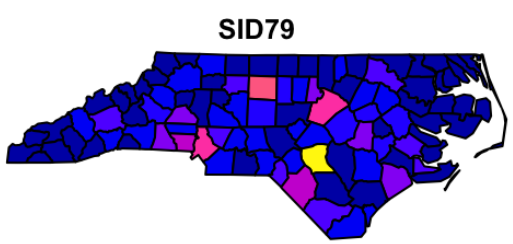


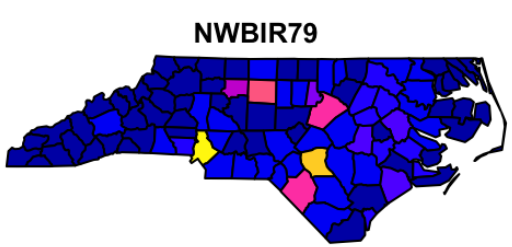






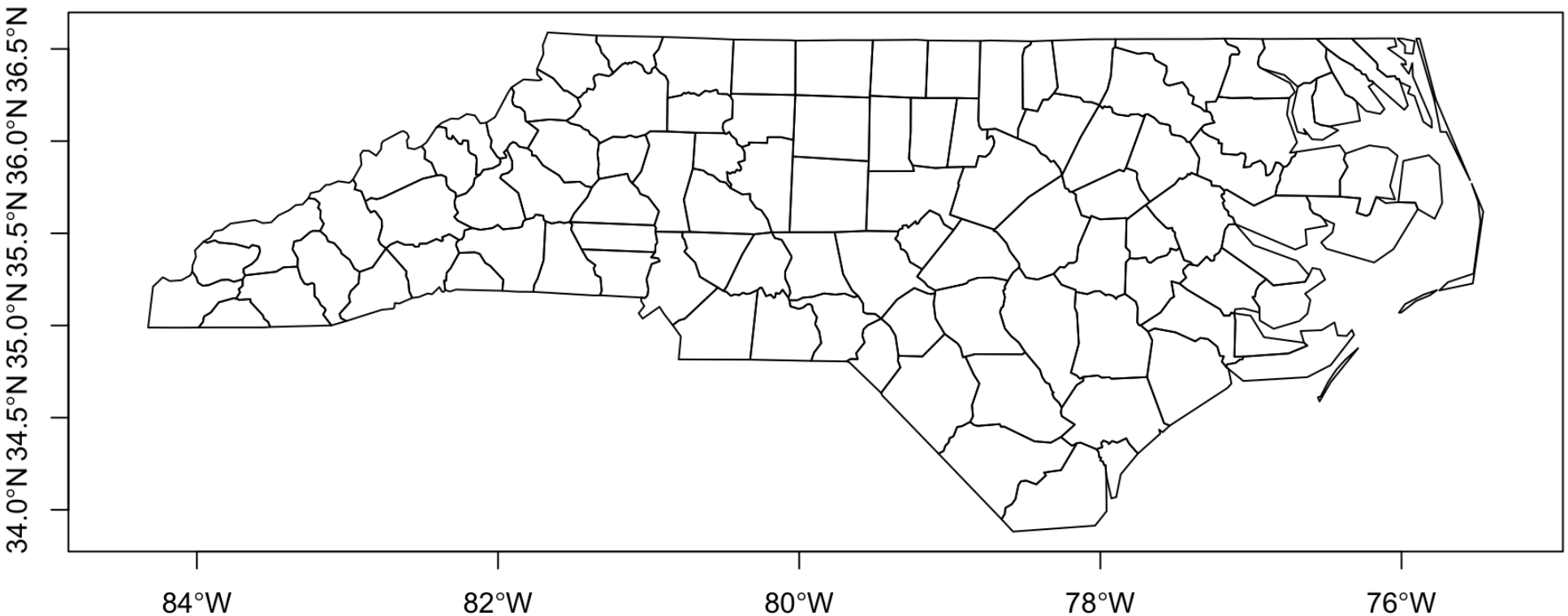






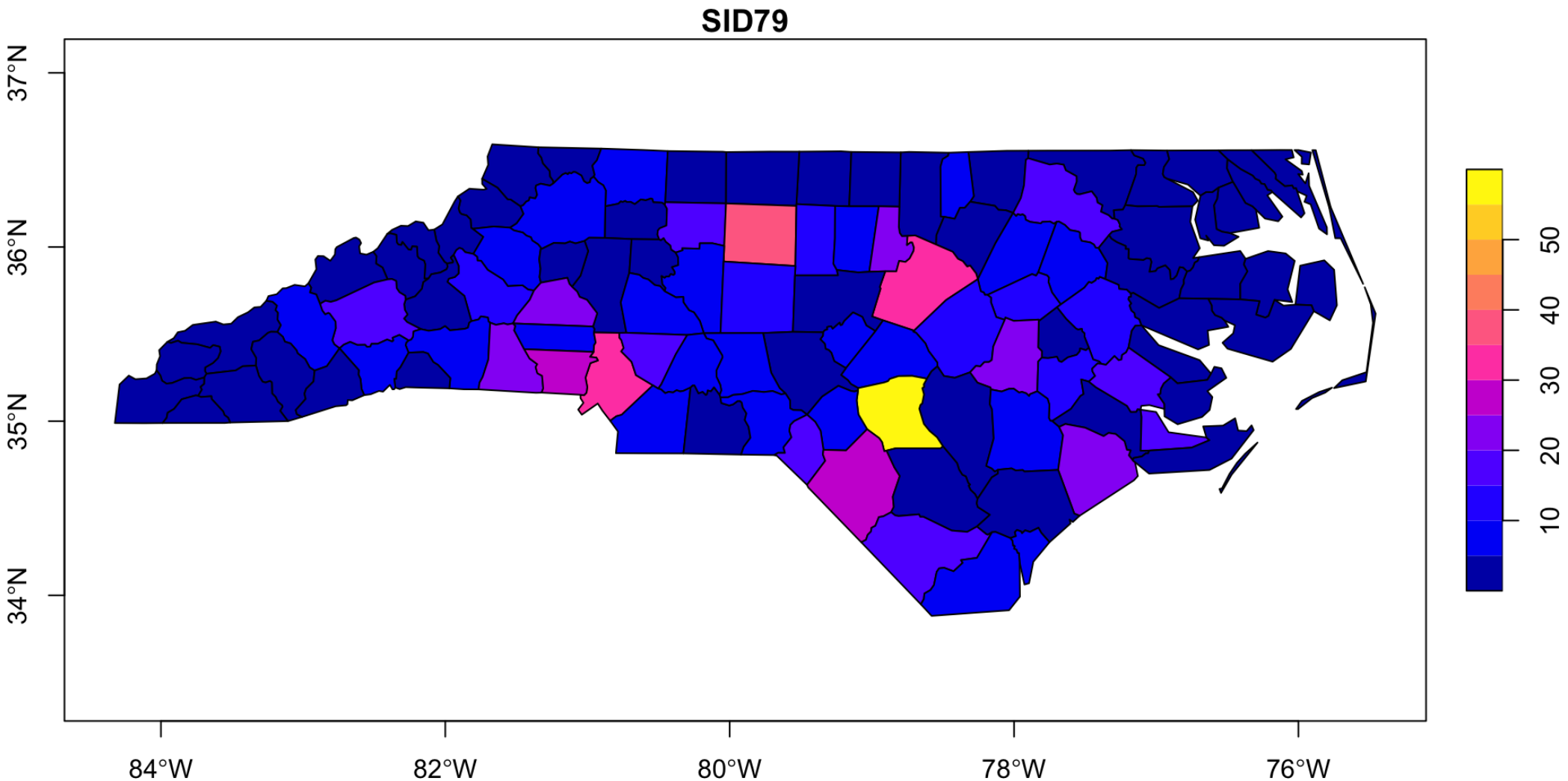
Geometry Plot

```
1  plot(st_geometry(nc), axes=TRUE)
```



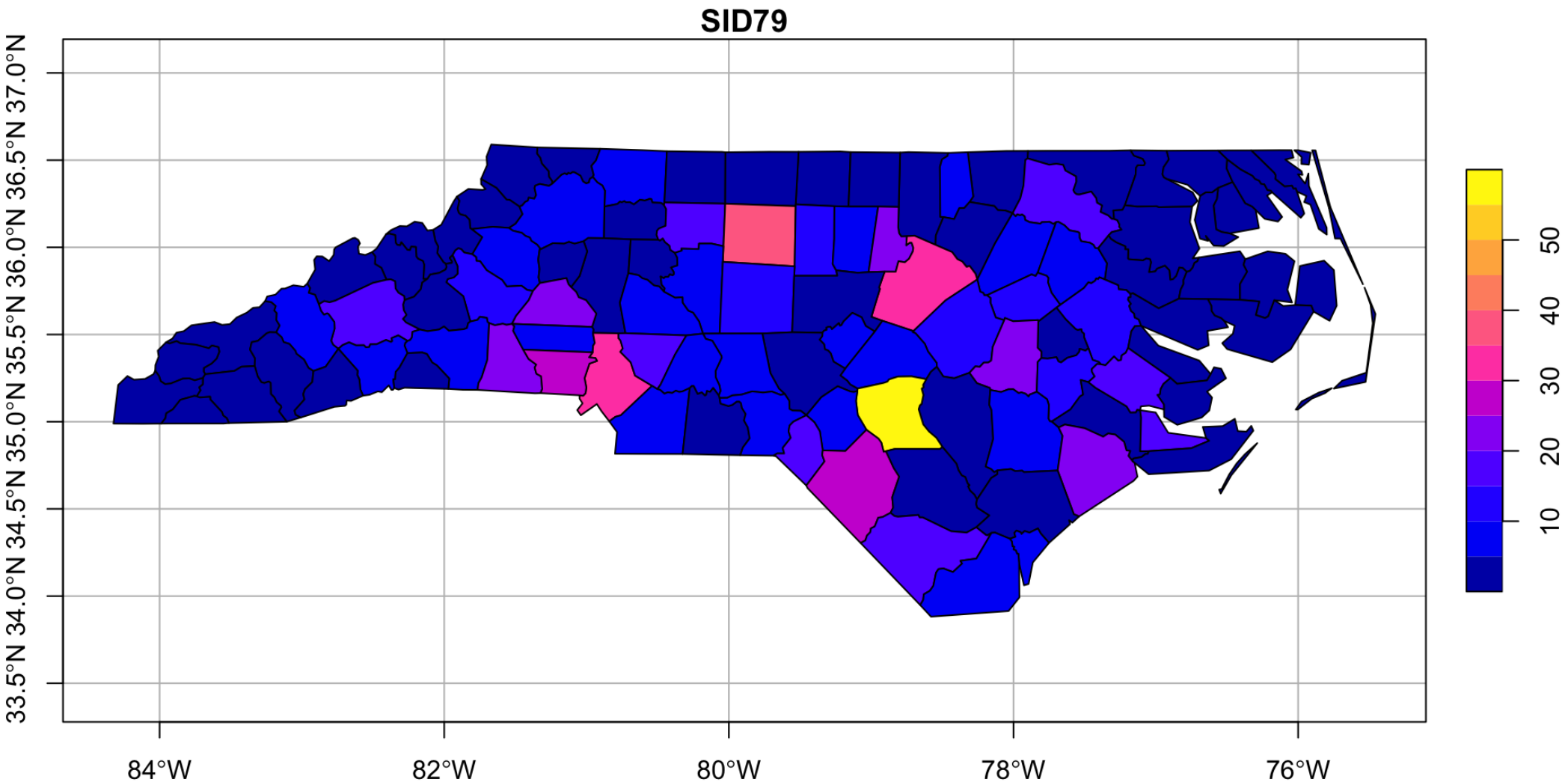
Graticules

```
1  plot(nc[,"SID79"], axes=TRUE)
```



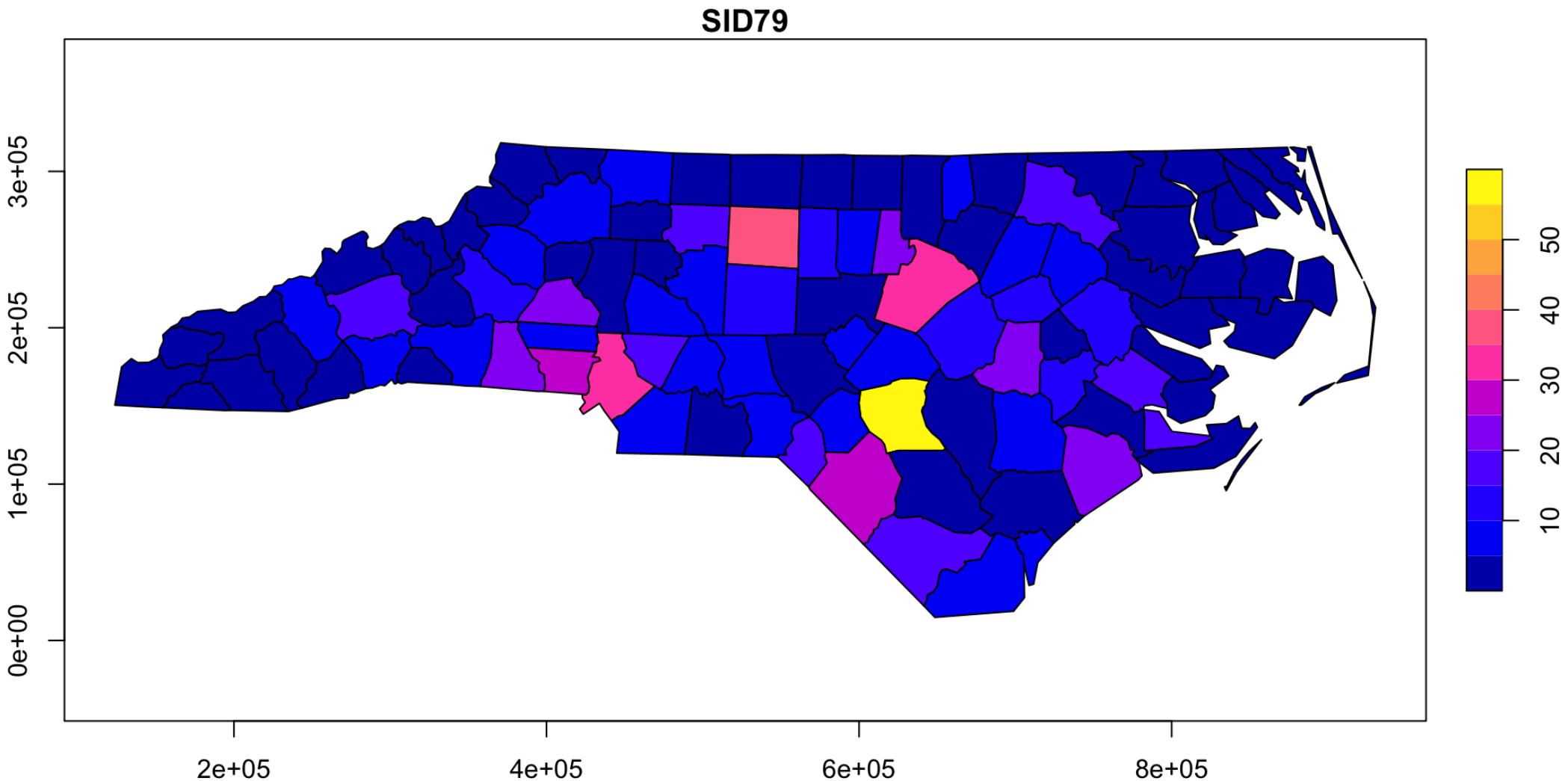
Graticules

```
1 plot(nc[,"SID79"], graticule=st_crs(nc), axes=TRUE)
```



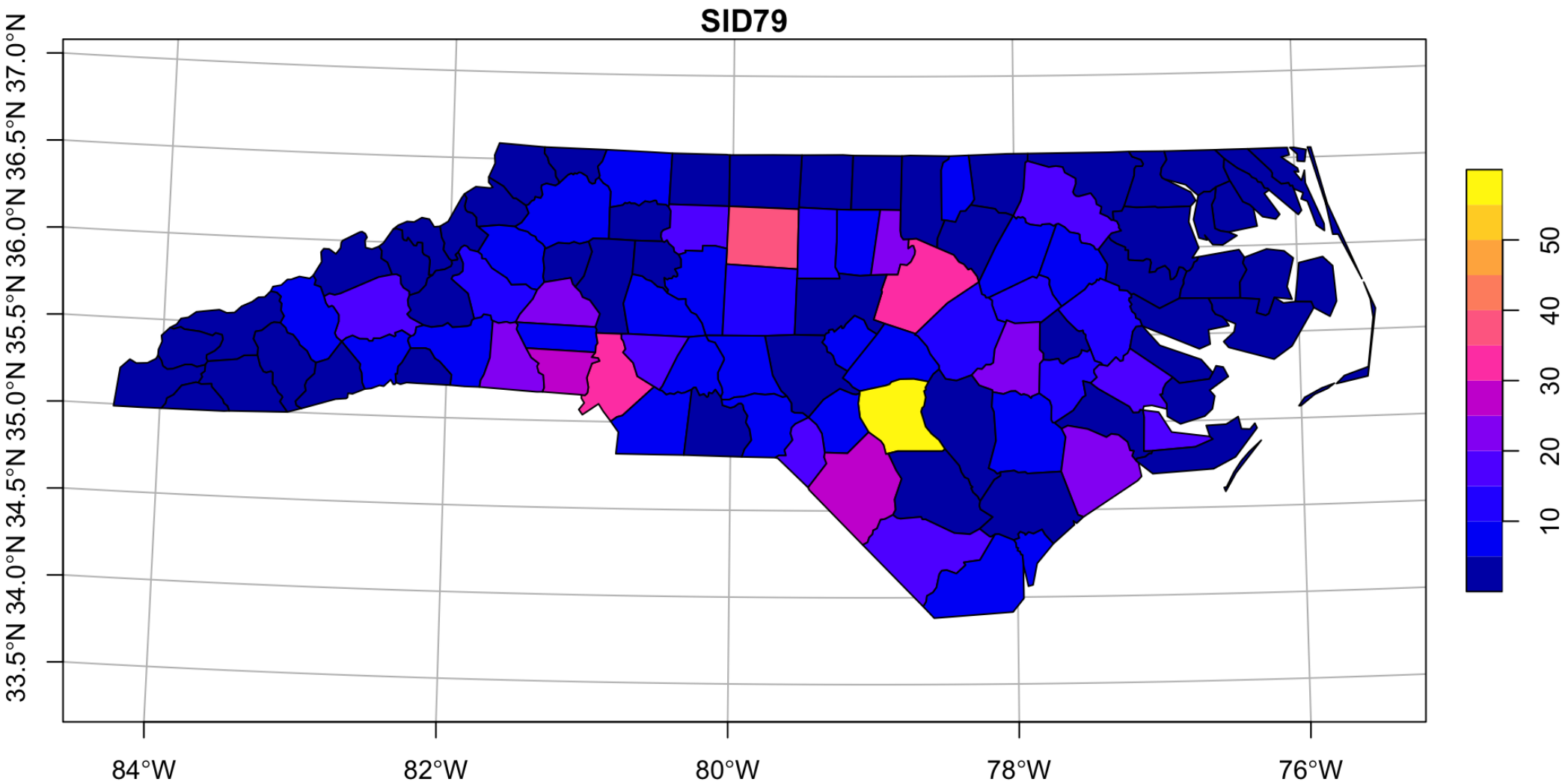
Graticules (EPSG:3631)

```
1 plot(st_transform(nc[,"SID79"], 3631), axes=TRUE)
```



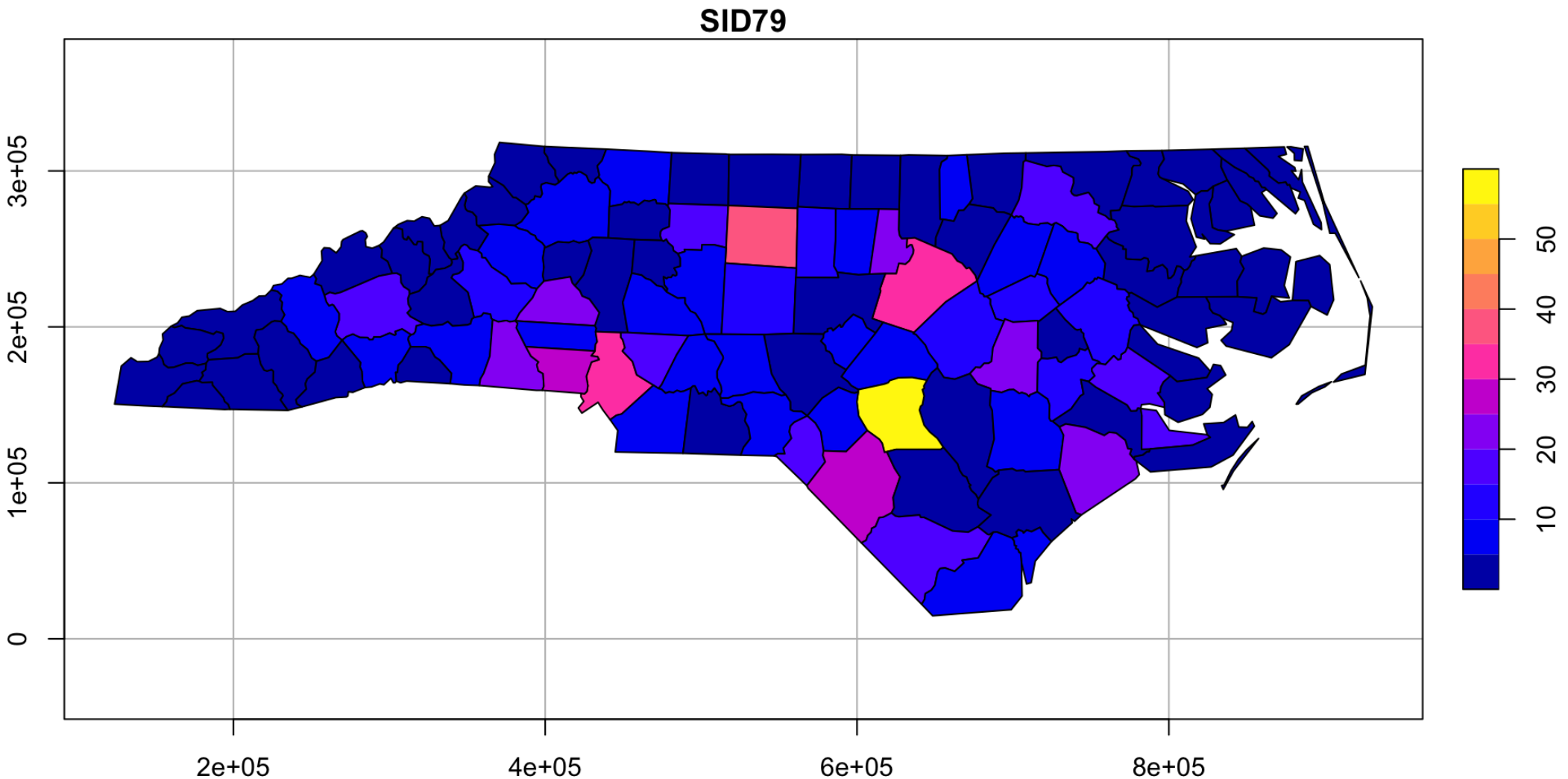
Graticules (EPSG:3631)

```
1 plot(st_transform(nc[,"SID79"], 3631), graticule=st_crs(nc), axes=TRUE)
```



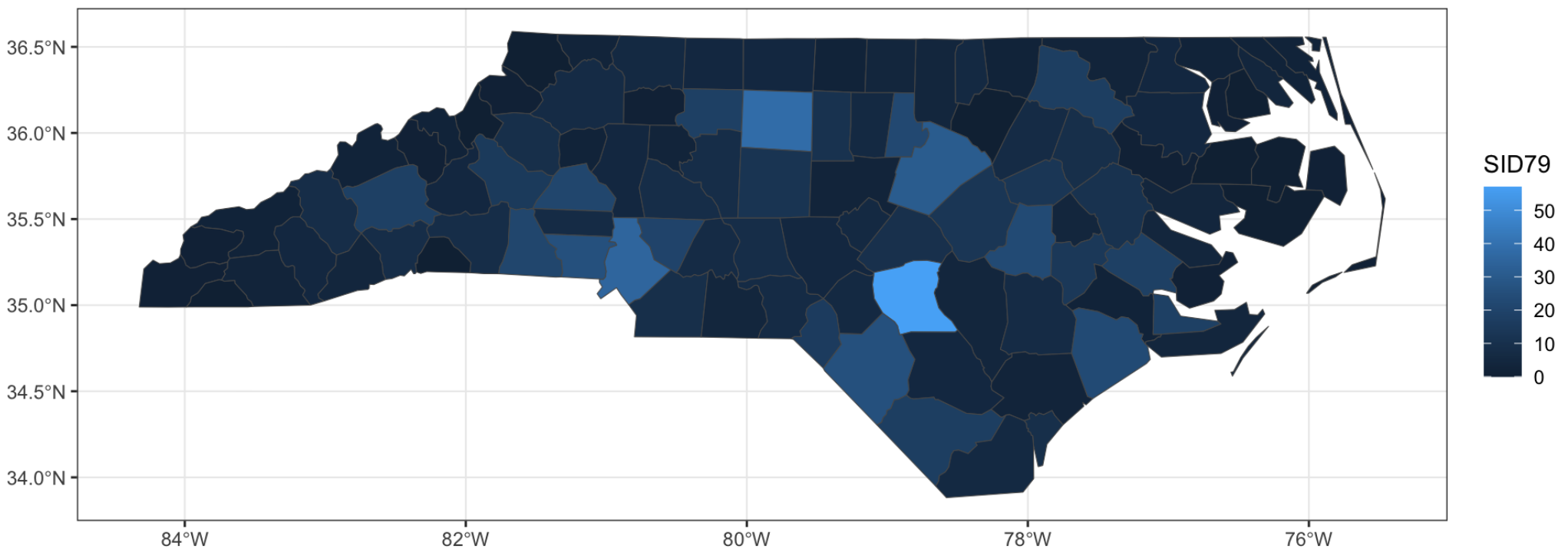
Graticules (EPSG:3631)

```
1 plot(st_transform(nc[,"SID79"], 3631), graticule=st_crs(3631), axes=TRUE
```



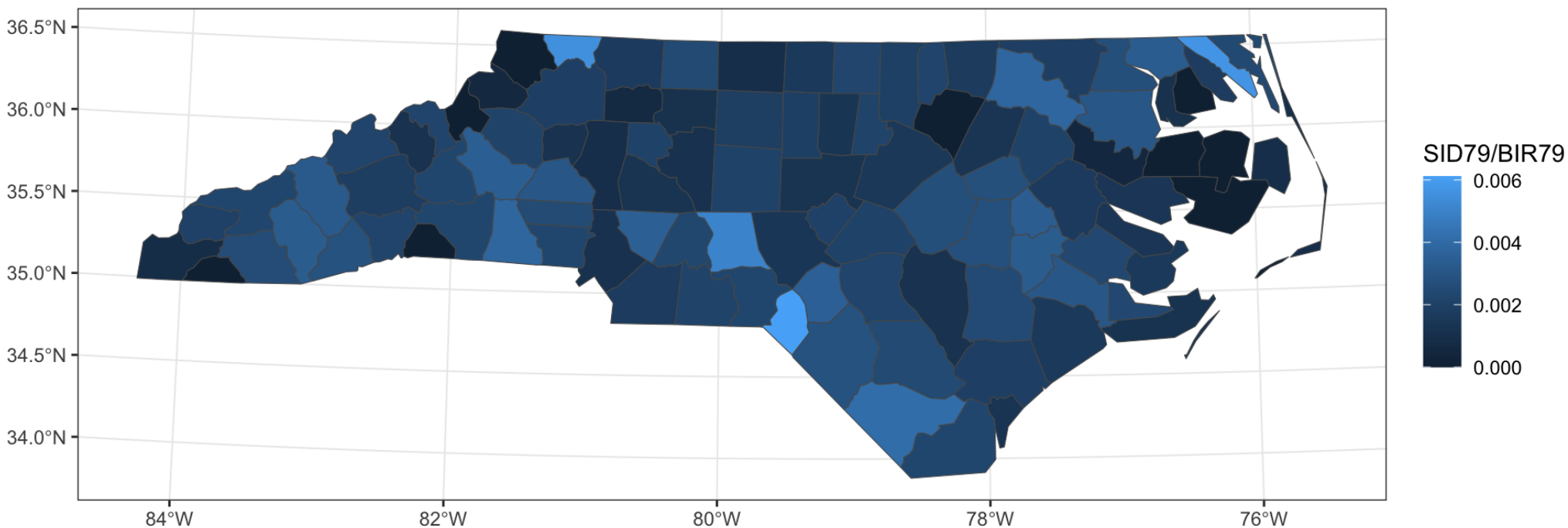
ggplot2

```
1  ggplot(nc) +
2    geom_sf(aes(fill=SID79))
```



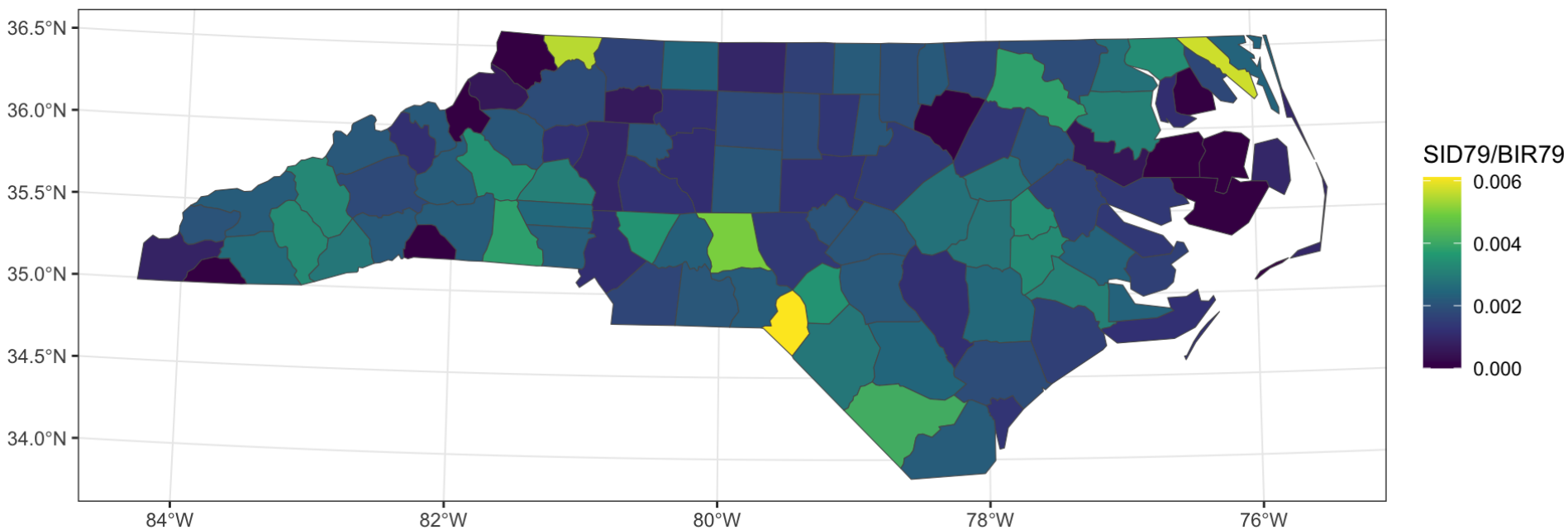
ggplot2 + projections

```
1  ggplot(st_transform(nc, 3631)) +
2    geom_sf(aes(fill=SID79 / BIR79))
```



ggplot2 + viridis

```
1 ggplot(st_transform(nc, 3631)) +
2   geom_sf(aes(fill=SID79 / BIR79)) +
3   scale_fill_viridis_c()
```



Example Data - Meuse

```r
data(meuse, meuse.riv, package="sp")
(meuse = st_as_sf(meuse, coords=c("x", "y"), crs=28992) |>
  as_tibble() |> st_as_sf())
```

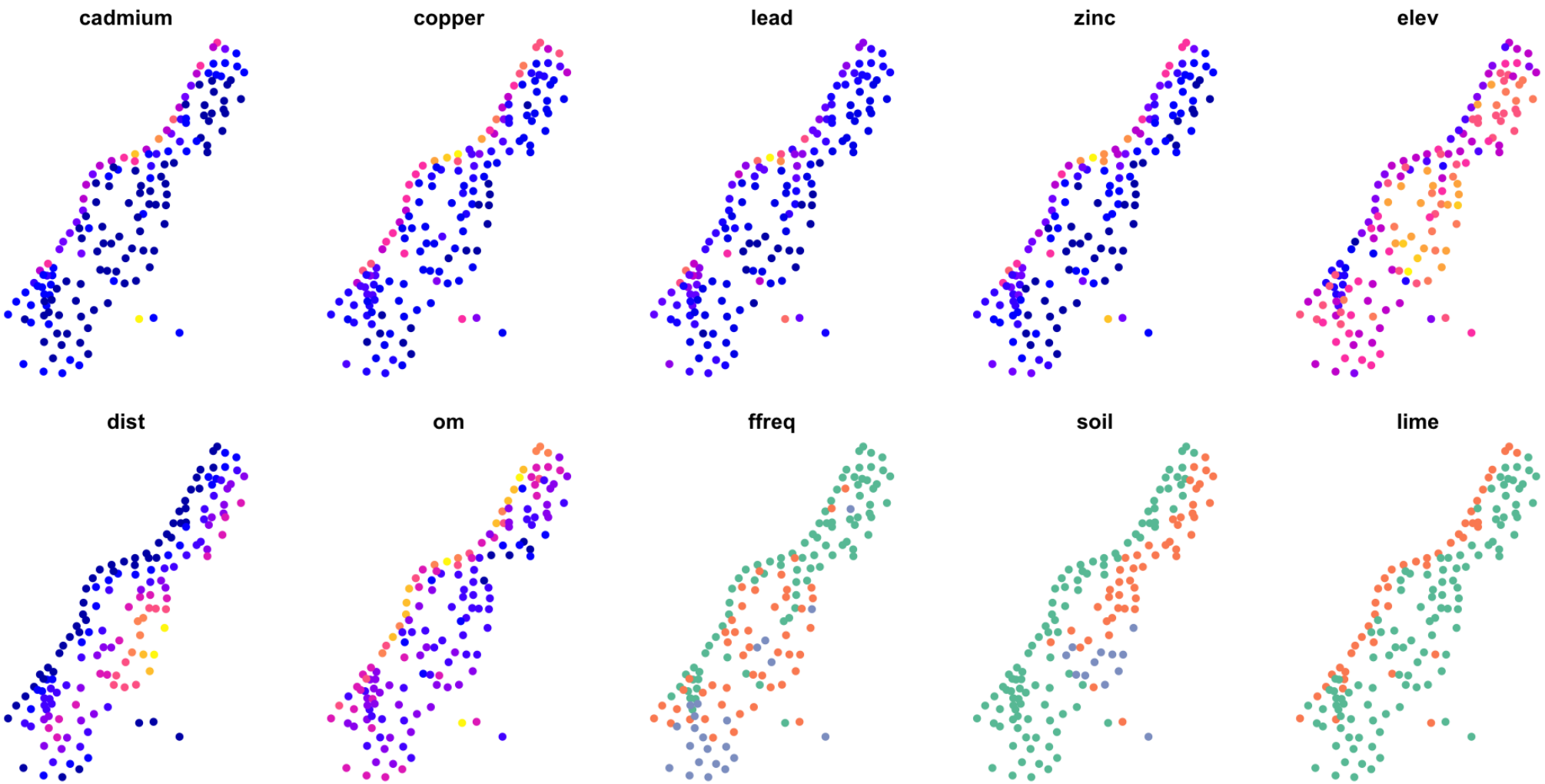
```
Simple feature collection with 155 features and 12 fields
Geometry type: POINT
Dimension:     XY
Bounding box:  xmin: 178605 ymin: 329714 xmax: 181390 ymax: 333611
Projected CRS: Amersfoort / RD New
# A tibble: 155 × 13
   cadmium copper  lead  zinc  elev    dist    om ffreq
     <dbl>  <dbl> <dbl> <dbl> <dbl>   <dbl> <dbl> <fct>
 1    11.7     85   299  1022  7.91 0.00136  13.6 1
 2     8.6     81   277  1141  6.98 0.0122   14   1
 3     6.5     68   199   640  7.8  0.103    13   1
 4     2.6     81   116   257  7.66 0.190     8   1
```

```r
( meuse_riv = st_polygon(list(meuse.riv)) |>
    st_sfc() |>
    st_set_crs(28992) |>
    st_as_sf()
)
```

```
Simple feature collection with 1 feature and 0 fields
Geometry type: POLYGON
Dimension:     XY
Bounding box:  xmin: 178304 ymin: 325698.5 xmax: 182331.5 ymax: 337684.8
Projected CRS: Amersfoort / RD New
                                 x
1 POLYGON ((182003.7 337678.6...
```

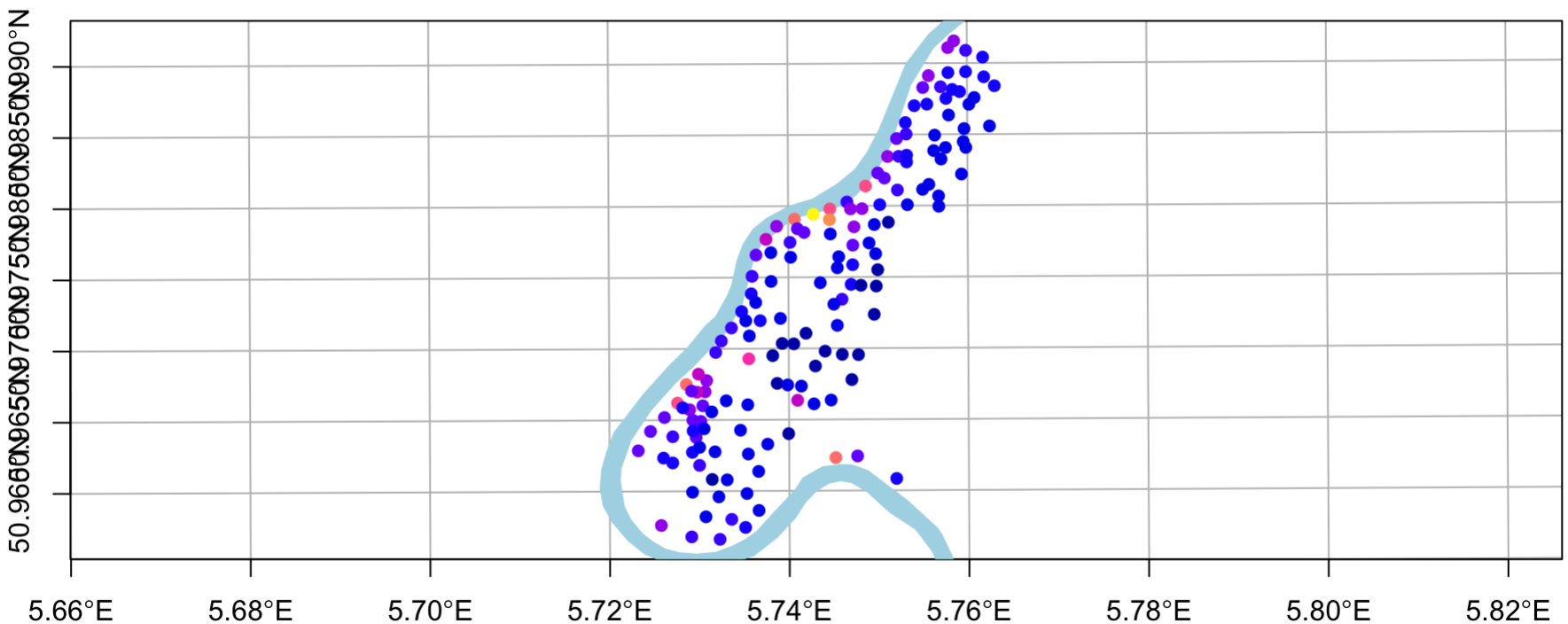
Meuse

```
1  plot(meuse, pch=16)
```



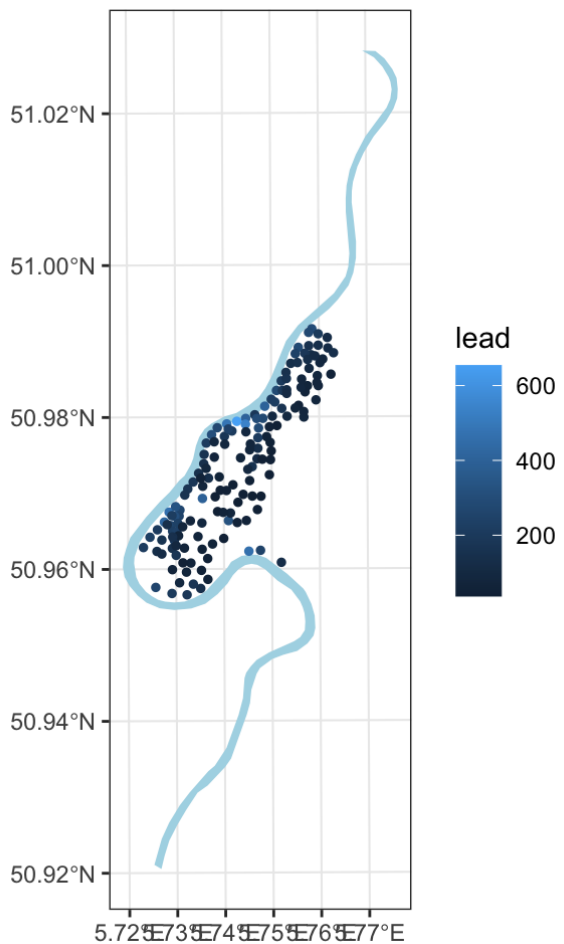
Layering plots

```
plot(meuse_riv, col=adjustcolor("lightblue", alpha.f=1), border = NA,
     axes=TRUE, graticule=st_crs(4326),
     xlim=st_bbox(meuse)[c(1,3)], ylim=st_bbox(meuse)[c(2,4)])
plot(meuse[,"lead"], pch=16, add=TRUE)
```



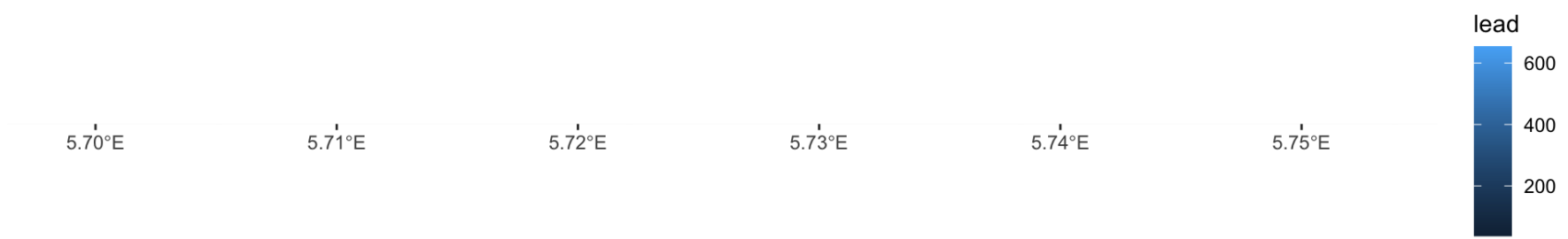
ggplot2

```
1  ggplot() +
2    geom_sf(data=meuse_riv, fill="lightblue", color=NA) +
3    geom_sf(data=meuse, aes(color=lead), size=1)
```



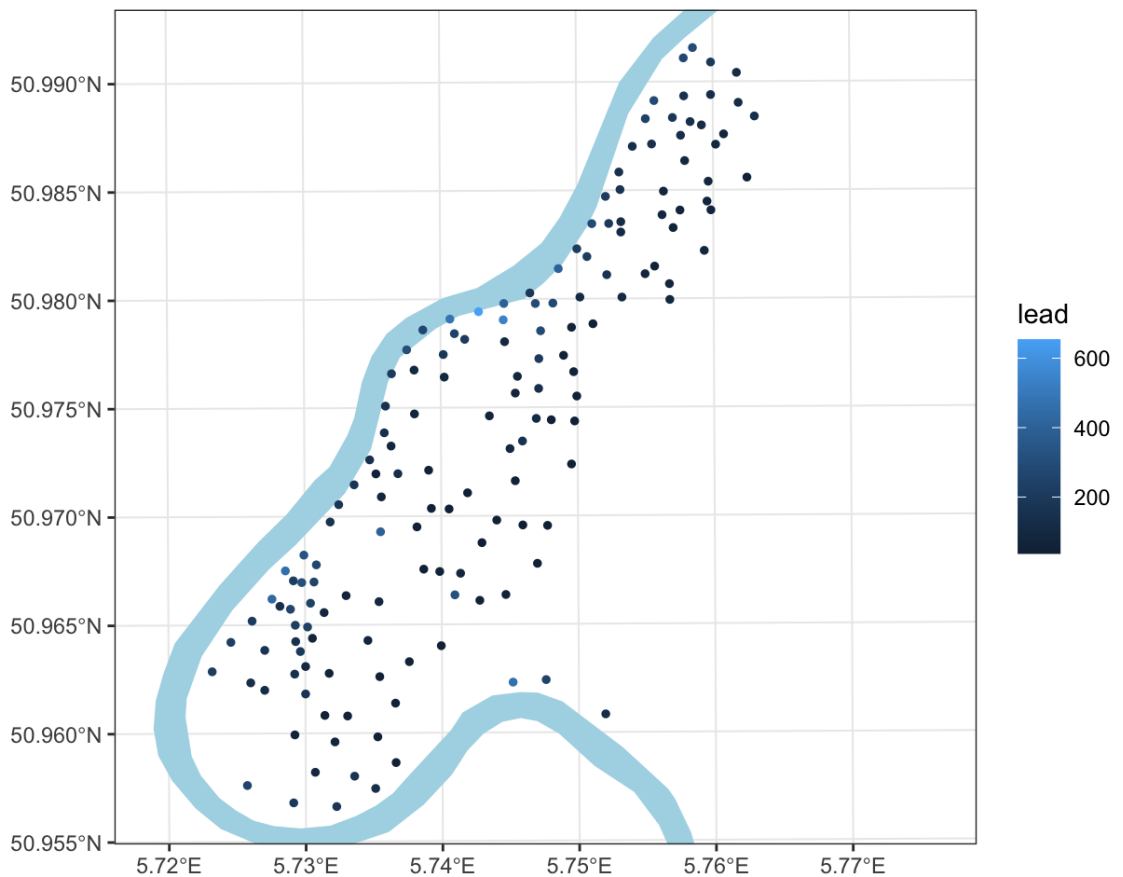
ggplot2 - axis limits

```
1 ggplot() +
2   geom_sf(data=meuse_riv, fill="lightblue", color=NA) +
3   geom_sf(data=meuse, aes(color=lead), size=1) +
4   ylim(50.95, 50.99)
```



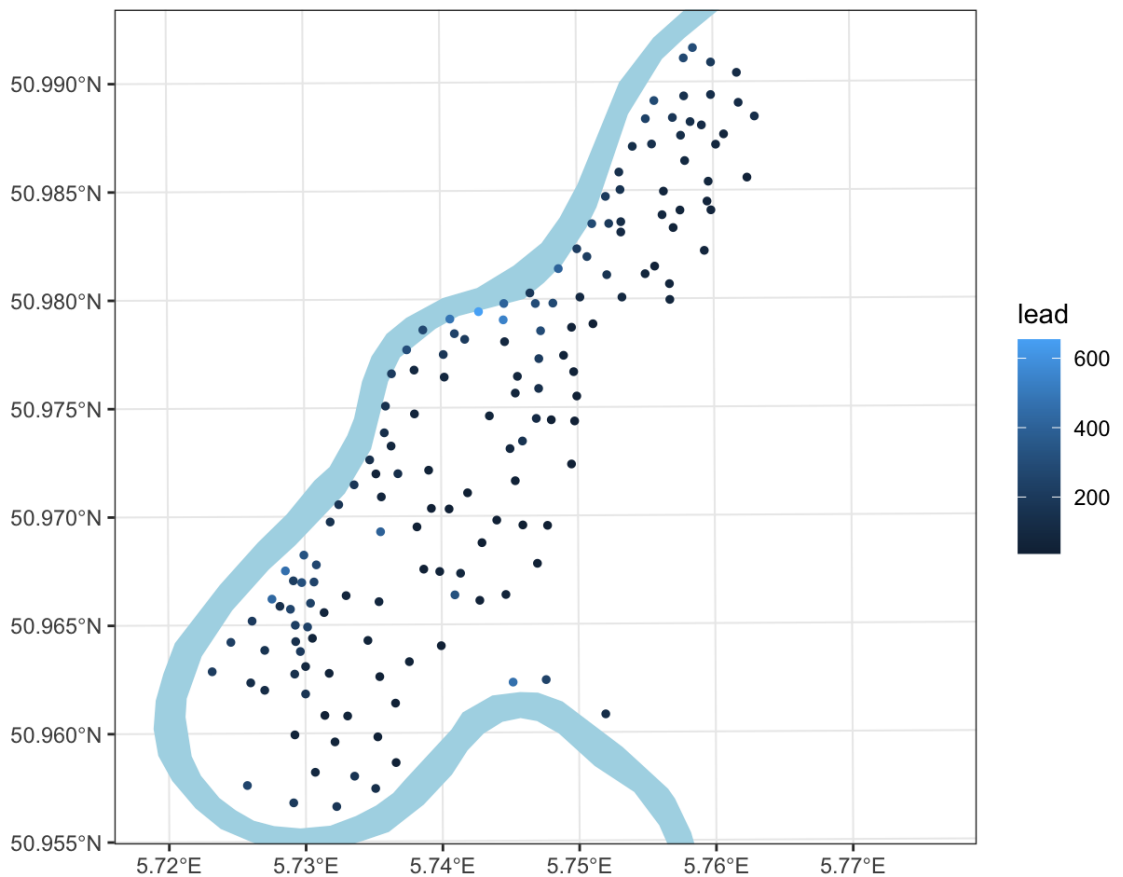
ggplot2 - axis limits

```
1  ggplot() +
2    geom_sf(data=meuse_riv, fill="lightblue", color=NA) +
3    geom_sf(data=meuse, aes(color=lead), size=1) +
4    ylim(329714, 333611)
```



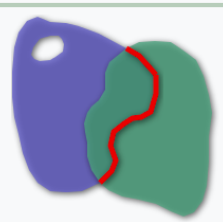
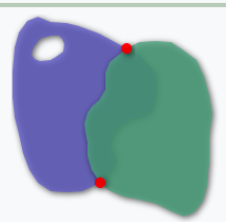
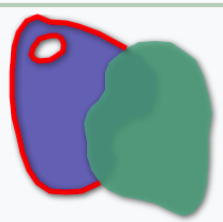
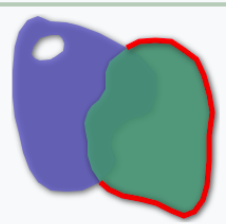
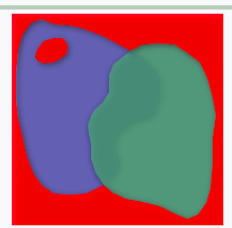
ggplot2 - bounding box

```
1  ggplot() +
2    geom_sf(data=st_sf(meuse_riv), fill="lightblue", color=NA) +
3    geom_sf(data=meuse, aes(color=lead), size=1) +
4    ylim(st_bbox(meuse)["ymin"], st_bbox(meuse)["ymax"])
```

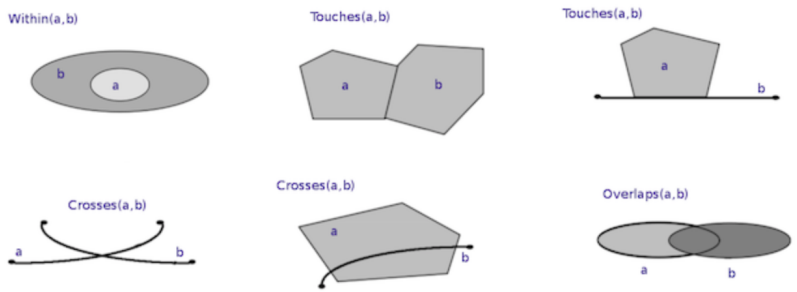


Geometry Predicates

DE-9IM

	Interior	Boundary	Exterior
Interior	 $\dim[I(a)\cap I(b)] = 2$	 $\dim[I(a)\cap B(b)] = 1$	 $\dim[I(a)\cap E(b)] = 2$
Boundary	 $\dim[B(a)\cap I(b)] = 1$	 $\dim[B(a)\cap B(b)] = 0$	 $\dim[B(a)\cap E(b)] = 1$
Exterior	 $\dim[E(a)\cap I(b)] = 2$	 $\dim[E(a)\cap B(b)] = 1$	 $\dim[E(a)\cap E(b)] = 2$

Spatial predicates



`st_within(a,b)`:

$$\begin{bmatrix} T & * & F \\ * & * & F \\ * & * & * \end{bmatrix}$$

`st_touches(a,b)`:

$$\begin{bmatrix} F & T & * \\ * & * & * \\ * & * & * \end{bmatrix} \cup \begin{bmatrix} F & * & * \\ T & * & * \\ * & * & * \end{bmatrix} \cup \begin{bmatrix} F & * & * \\ * & T & * \\ * & * & * \end{bmatrix}$$

Sparse vs Full Results

```
1 st_intersects(ncc[20:30,], air) %>% str()
```

```
List of 11
 $ : int(0)
 $ : int(0)
 $ : int(0)
 $ : int(0)
 $ : int(0)
 $ : int(0)
 $ : int 268
 $ : int 717
 $ : int(0)
 $ : int(0)
 $ : int(0)
 $ : int(0)
 - attr(*, "predicate")= chr "intersects"
 - attr(*, "region.id")= chr [1:11] "1" "2" "3" "4" ...
 - attr(*, "remove_self")= logi FALSE
 - attr(*, "retain_unique")= logi FALSE
```

```
1 st_intersects(ncc, air, sparse=FALSE) %>% str()
```

```
 logi [1:100, 1:940] FALSE FALSE FALSE FALSE FALSE FALSE ...
```

Examples

- Which counties have an airport?
- Which counties are adjacent to Durham County?
- Which counties have more than 4 neighbors?

```
ncc  = read_sf("data/gis/nc_counties/", quiet=TRUE)
air = read_sf("data/gis/airports/", quiet=TRUE) |> st_transform(st_crs(ncc))
hwy = read_sf("data/gis/us_interstates/", quiet=TRUE) |> st_transform(st_crs(ncc))
```

Which counties have an airport?

```
ncc |>
  mutate(
    airports = st_intersects(ncc, air) |> strip_attrs(),
    n_airports = purrr::map_int(airports, length)
  ) |>
  filter(n_airports > 0)
```

```
Simple feature collection with 16 features and 10 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -82.88783 ymin: 33.92835 xmax: -75.46003 ymax: 36.26165
Geodetic CRS:  NAD83
# A tibble: 16 × 11
     AREA PERIM…¹ COUNT…² STATE COUNTY FIPS  STATE…³ SQUAR…⁴
  *  <dbl>   <dbl>   <dbl> <chr> <chr>  <chr> <chr>     <dbl>
 1 0.107     1.54    2065 NC    Forsy… 37067 37          413.
 2 0.170     1.69    2069 NC    Guilf… 37081 37          658.
 3 0.0996    6.15    2077 NC    Dare … 37055 37          386.
 4 0.221     2.14    2106 NC    Wake … 37183 37          858.
 5 0.169     2.12    2151 NC    Pitt … 37147 37          654.
 6 0.106     1.56    2152 NC    Cataw… 37035 37          413.
 7 0.170     2.37    2153 NC    Bunco… 37021 37          660.
 8 0.143     1.71    2197 NC    Wayne… 37191 37          557.
```

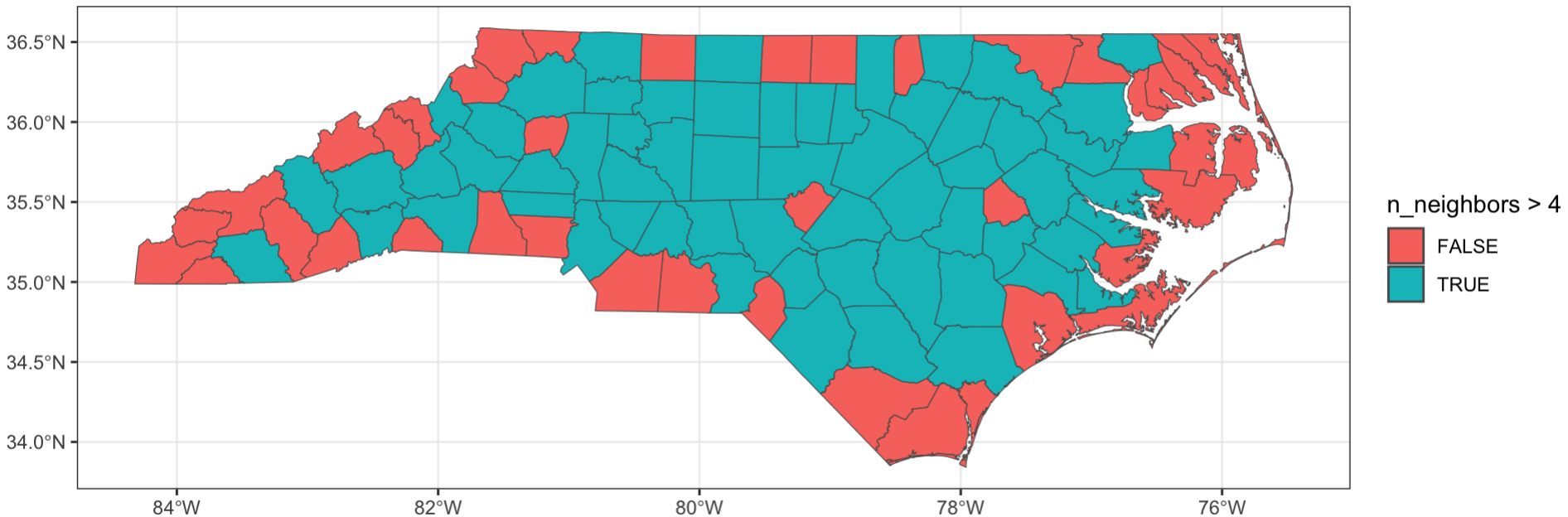
Which counties are adjacent to Durham County?

```
ncc |>
  mutate(
    touch_durham = st_touches(ncc, ncc |> filter(COUNTY == "Durham County")) |> strip_attrs(),
    n_touches = map_int(touch_durham, length)
  ) |>
  filter(n_touches > 0)
```

```
Simple feature collection with 5 features and 10 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -79.55573 ymin: 35.51505 xmax: -78.25503 ymax: 36.54245
Geodetic CRS:  NAD83
# A tibble: 5 × 11
   AREA PERIMETER COUNT…¹ STATE COUNTY FIPS  STATE…² SQUAR…³
* <dbl>     <dbl>   <dbl> <chr> <chr>  <chr> <chr>     <dbl>
1 0.105      1.30    2006 NC    Perso… 37145 37          404.
2 0.139      1.69    2008 NC    Granv… 37077 37          536.
3 0.104      1.30    2074 NC    Orang… 37135 37          401.
4 0.221      2.14    2106 NC    Wake … 37183 37          858.
5 0.183      2.26    2141 NC    Chath… 37037 37          710.
# … with 3 more variables: geometry <MULTIPOLYGON [°]>,
#   touch_durham <list>, n_touches <int>, and abbreviated
#   variable names ¹COUNTYP010, ²STATE_FIPS, ³SQUARE_MIL
```

Which counties have more than 4 neighbors?

```
ncc |>
  mutate(
    neighbors = st_touches(ncc) |> strip_attrs(),
    n_neighbors = map_int(neighbors, length)
  ) |>
  ggplot(aes(fill = n_neighbors > 4)) +
    geom_sf()
```


36.5°N
36.0°N
35.5°N
35.0°N
34.5°N
34.0°N
84°W
82°W
80°W
78°W
76°W
n_neighbors > 4
FALSE
TRUE

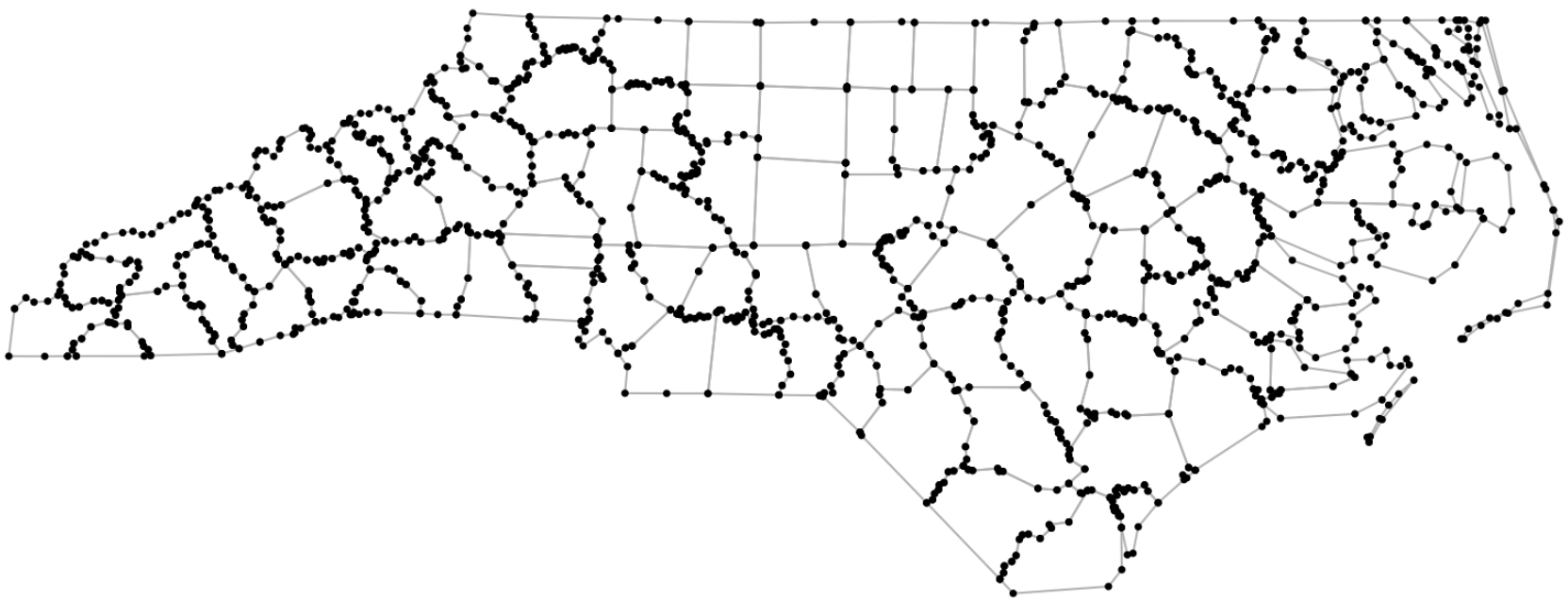
Geometry Manipulation

Casting

```
1 (nc_pts = st_cast(nc, "MULTIPOINT"))
```

```
Simple feature collection with 100 features and 7 fields
Geometry type: MULTIPOINT
Dimension:     XY
Bounding box:  xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax:
36.58965
Geodetic CRS:  NAD27
# A tibble: 100 × 8
   NAME        BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79
   <chr>       <dbl> <dbl>   <dbl> <dbl> <dbl>   <dbl>
 1 Ashe         1091     1      10  1364     0      19
 2 Alleghany     487     0      10   542     3      12
 3 Surry        3188     5     208  3616     6     260
```

```r
plot(st_geometry(nc), border='grey')
plot(st_geometry(nc_pts), pch=16, cex=0.5, add=TRUE)
```

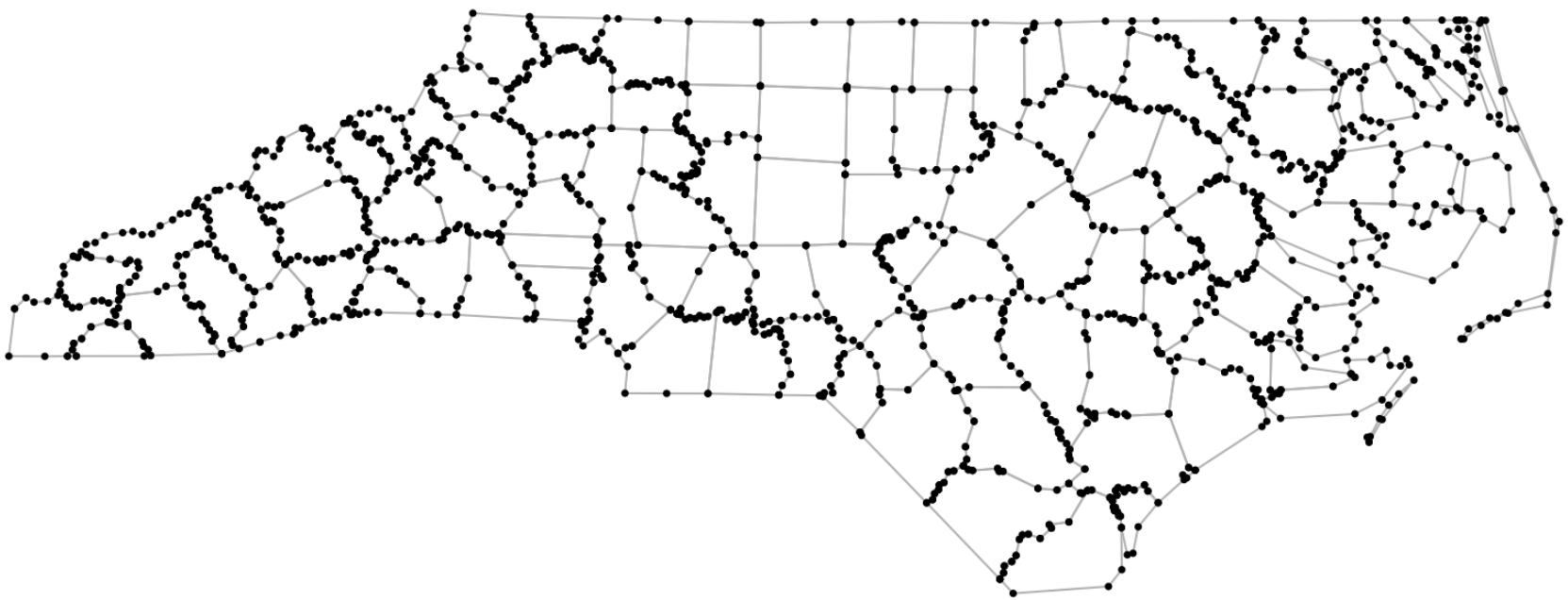


Casting - POINT

```
1 st_cast(nc, "POINT")
```

```
Simple feature collection with 2529 features and 7 fields
Geometry type: POINT
Dimension:     XY
Bounding box:  xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax:
36.58965
Geodetic CRS:  NAD27
# A tibble: 2,529 × 8
   NAME  BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79
   <chr> <dbl> <dbl>   <dbl> <dbl> <dbl>   <dbl>
 1 Ashe   1091     1      10  1364     0      19
 2 Ashe   1091     1      10  1364     0      19
 3 Ashe   1091     1      10  1364     0      19
```

```r
plot(st_geometry(nc), border='grey')
plot(st_geometry(st_cast(nc, "POINT")), pch=16, cex=0.5, add=TRUE)
```

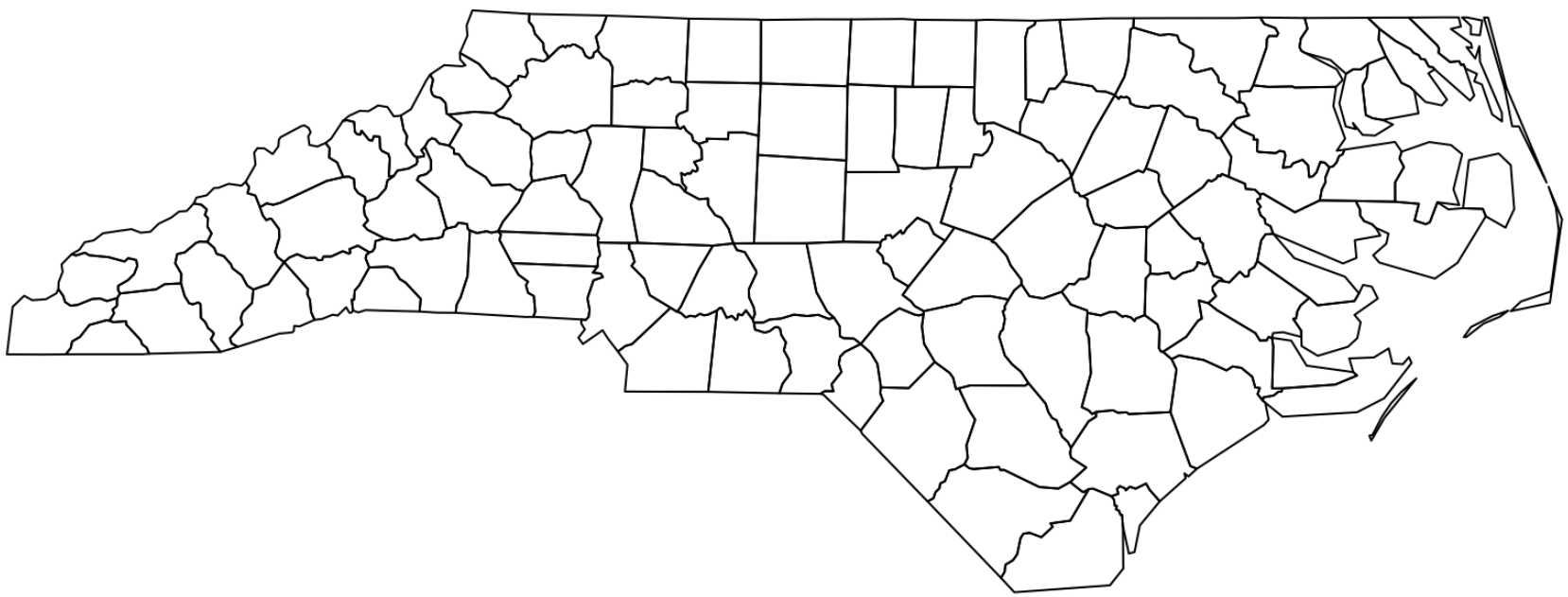


Casting - LINESTRING

```
1 st_cast(nc, "MULTILINESTRING")
```

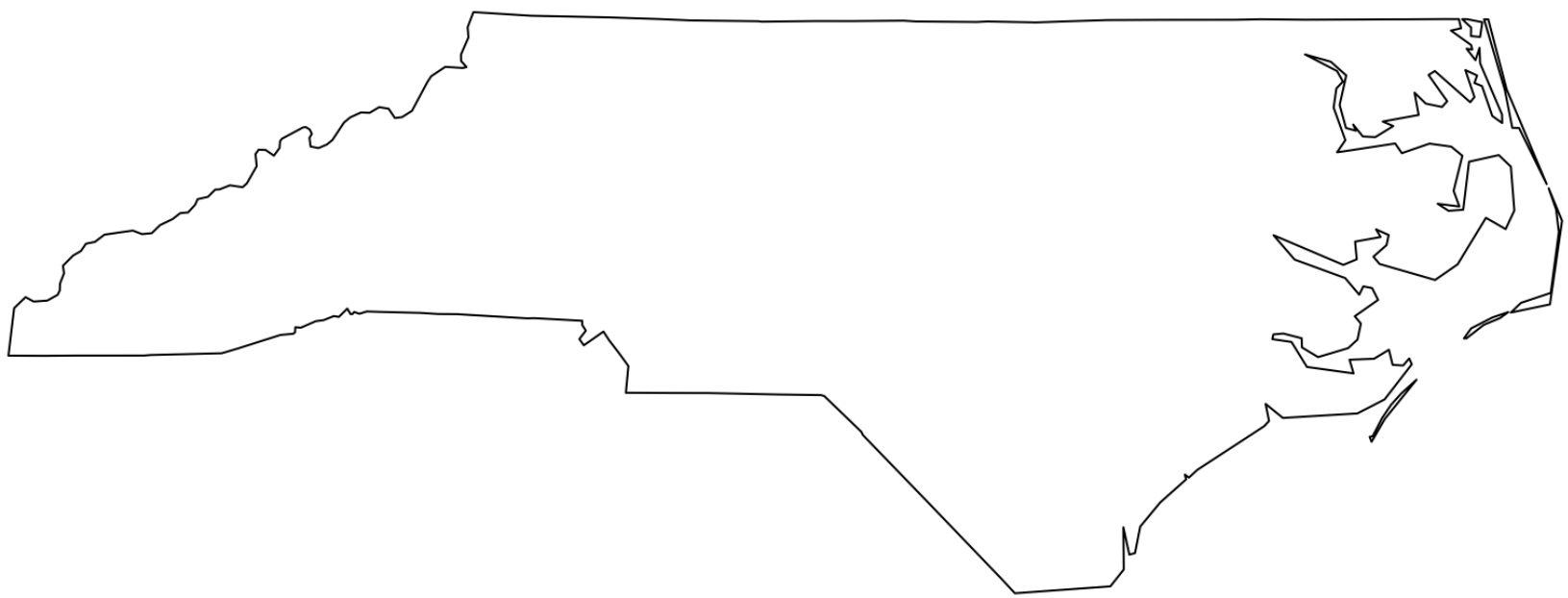
```
Simple feature collection with 100 features and 7 fields
Geometry type: MULTILINESTRING
Dimension:     XY
Bounding box:  xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax:
36.58965
Geodetic CRS:  NAD27
# A tibble: 100 × 8
   NAME        BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79
   <chr>       <dbl> <dbl>   <dbl> <dbl> <dbl>   <dbl>
 1 Ashe         1091     1      10  1364     0      19
 2 Alleghany     487     0      10   542     3      12
 3 Surry        3188     5     208  3616     6     260
```

```
1 st_cast(nc, "MULTILINESTRING") |> st_geometry() |> plot()
```



Grouping Features

```
1 nc_state = st_union(nc)
2 plot(nc_state)
```

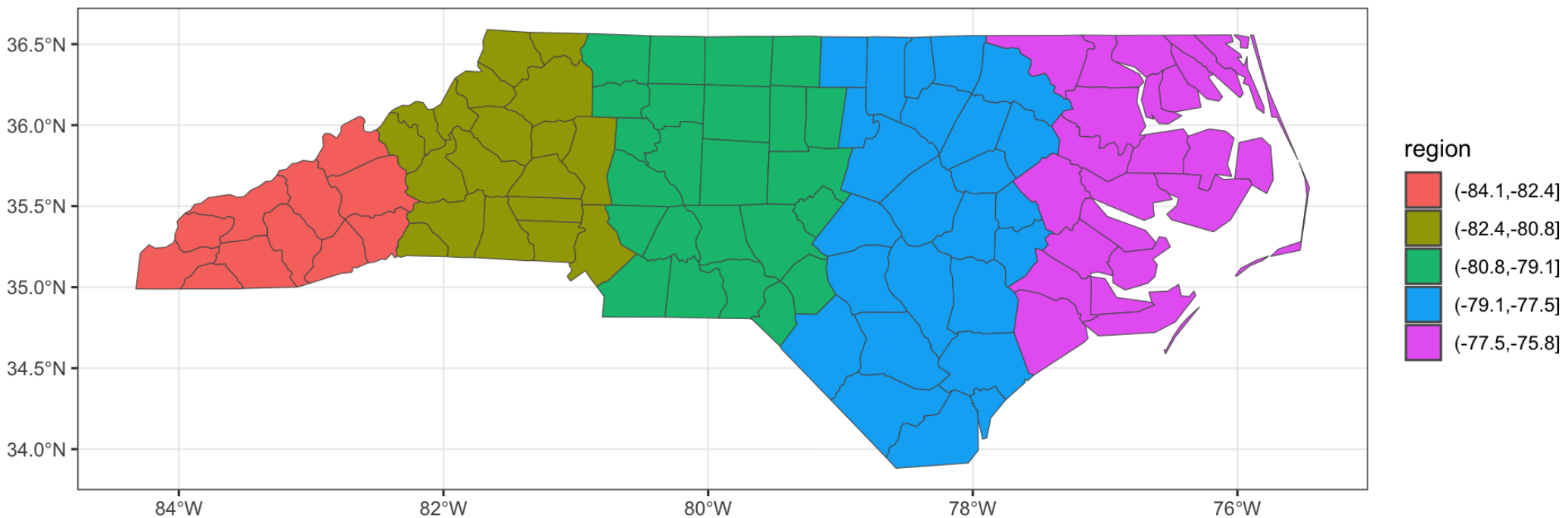


More Grouping

```
( nc_cut = nc |>
    mutate(X = st_centroid(nc) |> st_coordinates() |> (\(x) x[,1])()) |>
    mutate(region = cut(X, breaks = 5)) )
```

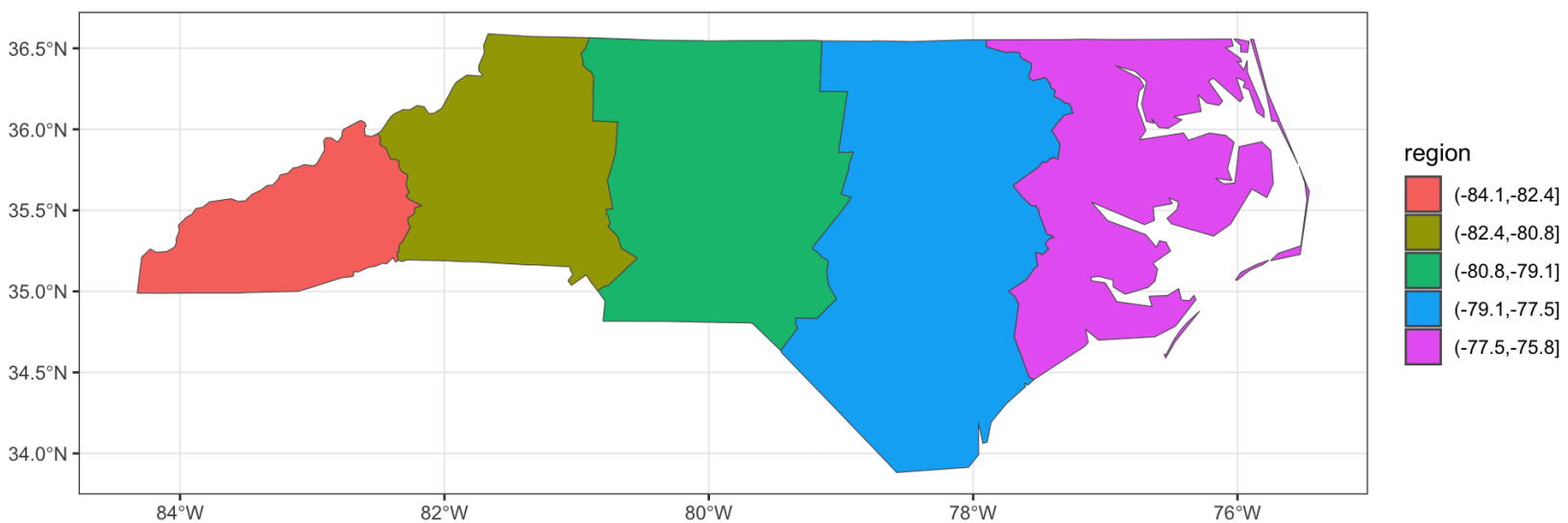
```
Simple feature collection with 100 features and 9 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax:
36.58965
Geodetic CRS:  NAD27
# A tibble: 100 × 10
   NAME        BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79
 * <chr>       <dbl> <dbl>   <dbl> <dbl> <dbl>   <dbl>
 1 Ashe         1091     1      10  1364     0      19
 2 Alleghany     487     0      10   542     3      12
 3 Surry        3188     5     208  3616     6     260
```

```
ggplot(nc_cut) +
  geom_sf(aes(fill=region))
```



dplyr and sf

```
nc_cut |>
  group_by(region) |>
  summarize() |>
  ggplot() +
    geom_sf(aes(fill=region))
```

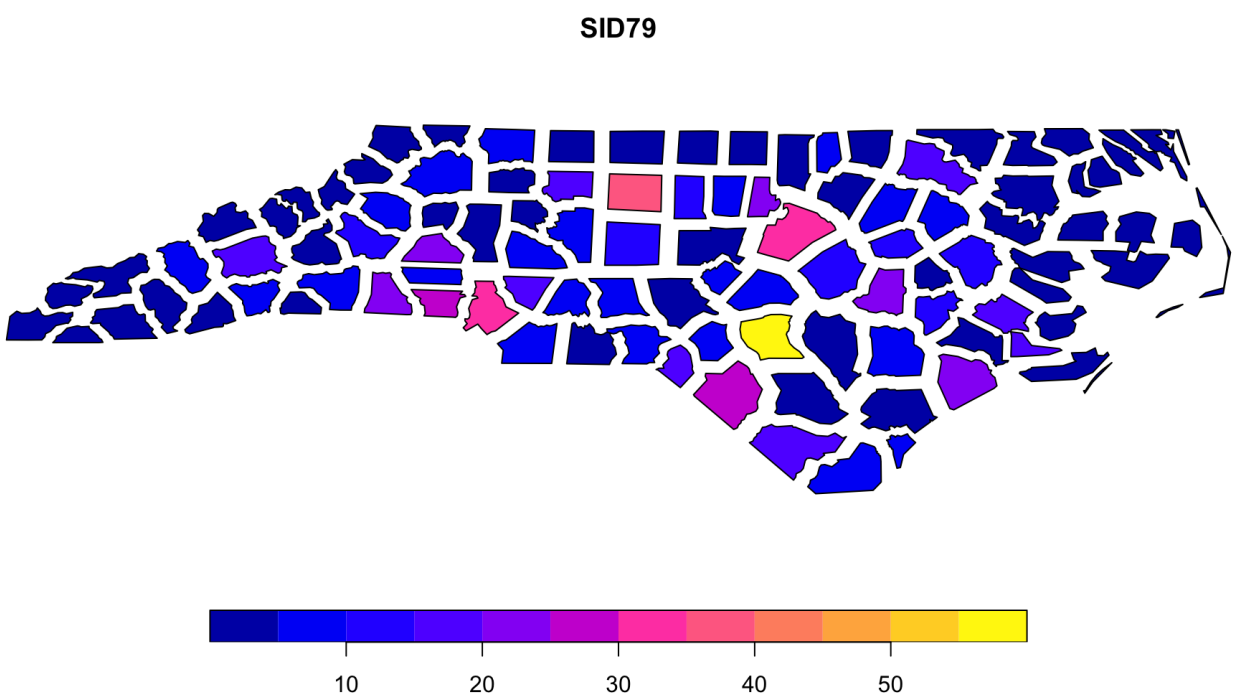


Affine Transfomations

```
1 rotate = function(a) matrix(c(cos(a), sin(a), -sin(a), cos(a)), 2, 2)
2
3 ctrd = st_centroid(nc_state)
4 state_rotate = (nc_state) * rotate(-pi/4)
5 plot(state_rotate, axes=TRUE)
```

Scaling Size

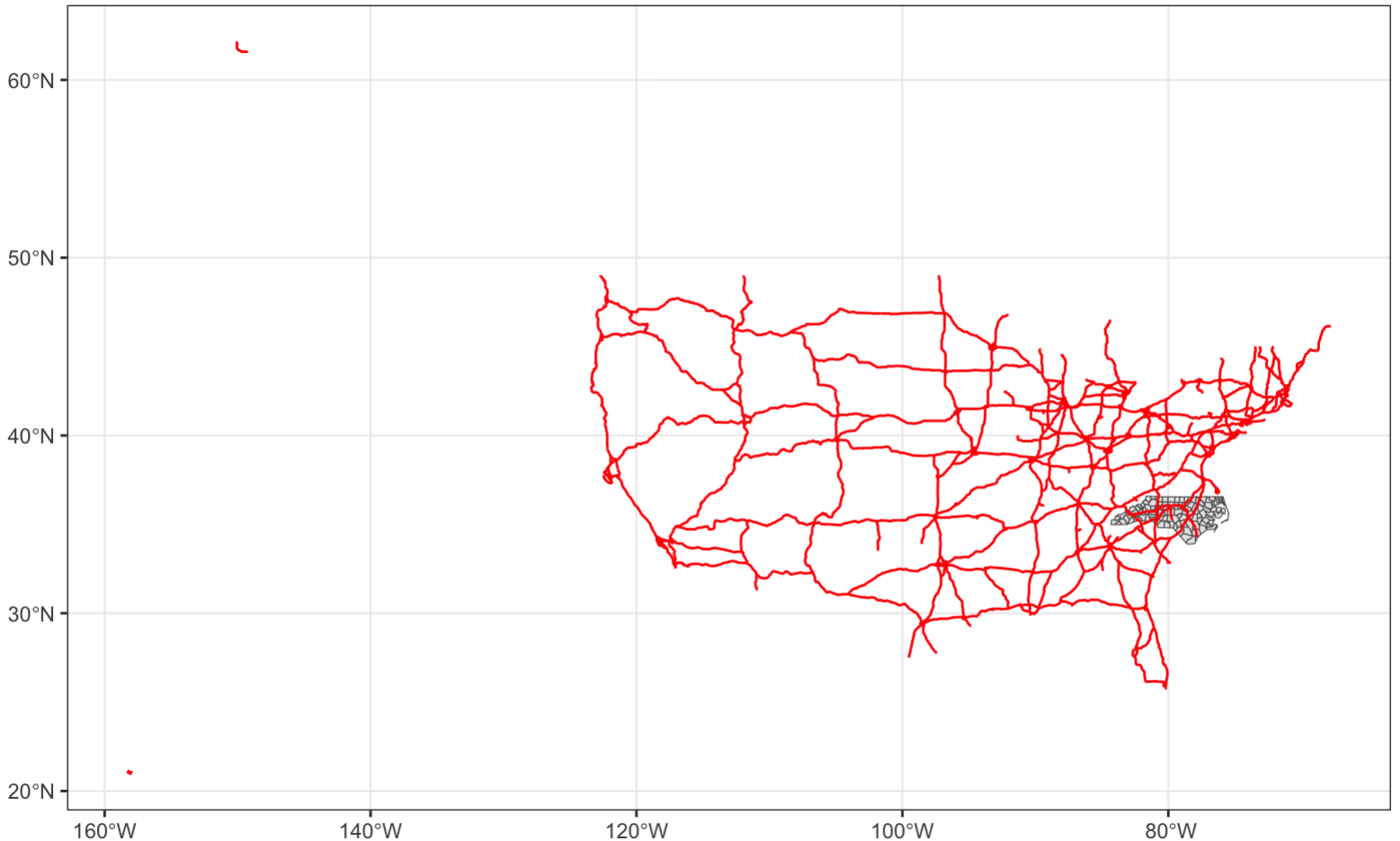
```
1 ctrd = st_centroid(st_geometry(nc))
2 area = st_area(nc) |> strip_attrs()
3
4 nc_rot = nc
5 st_geometry(nc_rot) = (st_geometry(nc) - ctrd) * 0.75 + ctrd
6
7 plot(nc_rot[,"SID79"])
```



Highway Example

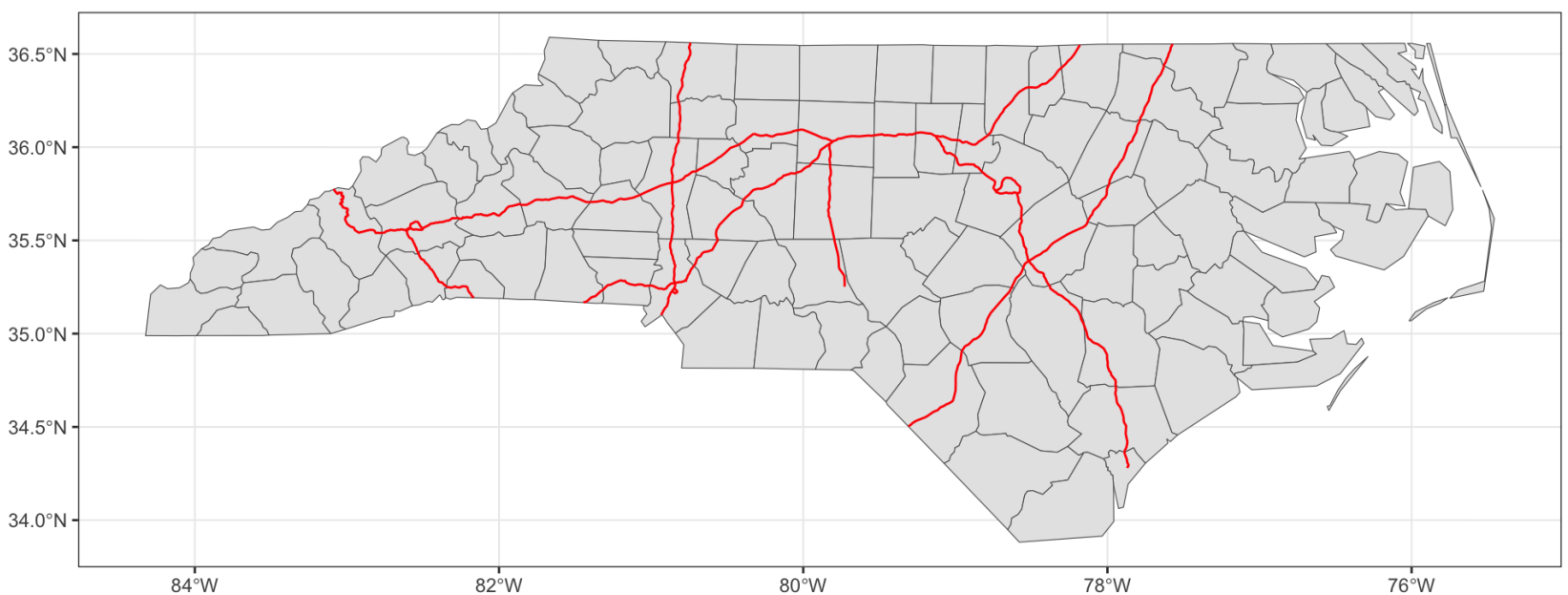
Highways

```
hwy = read_sf("data/us_interstates.gpkg", quiet = TRUE) |>
  st_transform(st_crs(nc))

ggplot() +
  geom_sf(data=nc) +
  geom_sf(data=hwy, col='red')
```


60°N
50°N
40°N
30°N
20°N
160°W
140°W
120°W
100°W
80°W

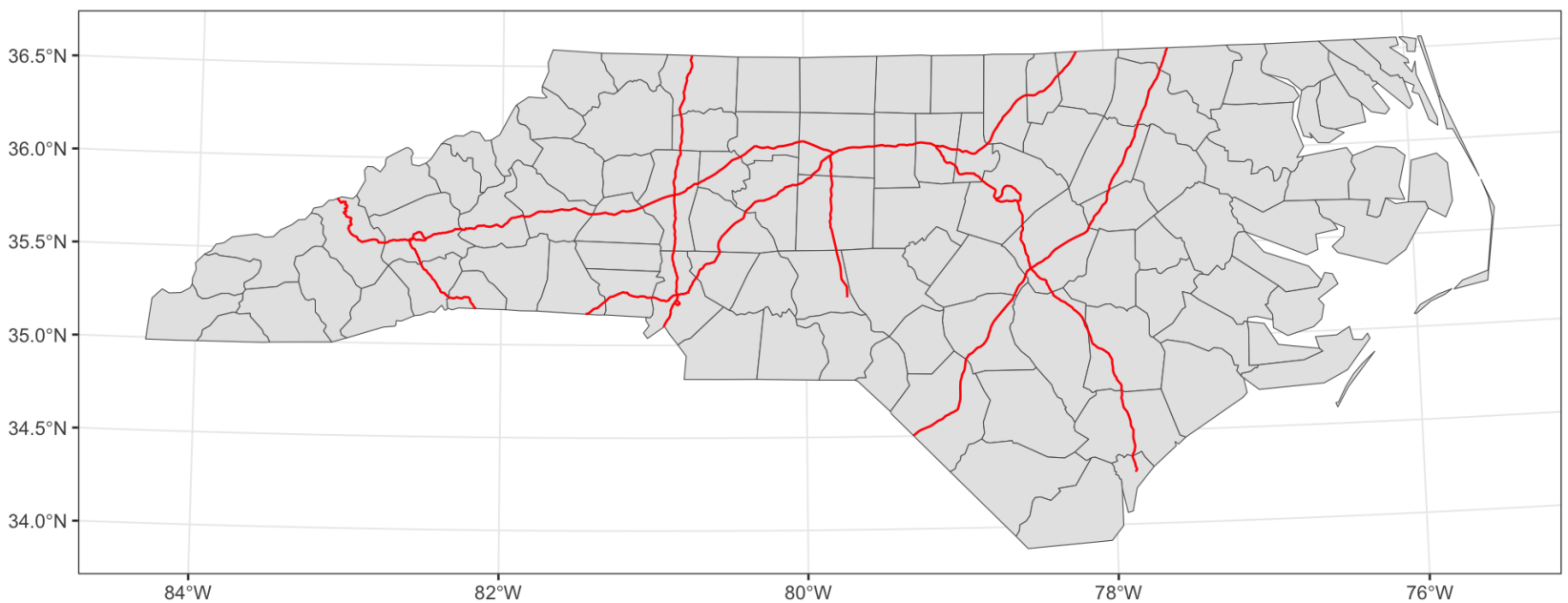
NC Interstate Highways

```
hwy_nc = st_intersection(hwy, nc)

ggplot() +
  geom_sf(data=nc) +
  geom_sf(data=hwy_nc, col='red')
```



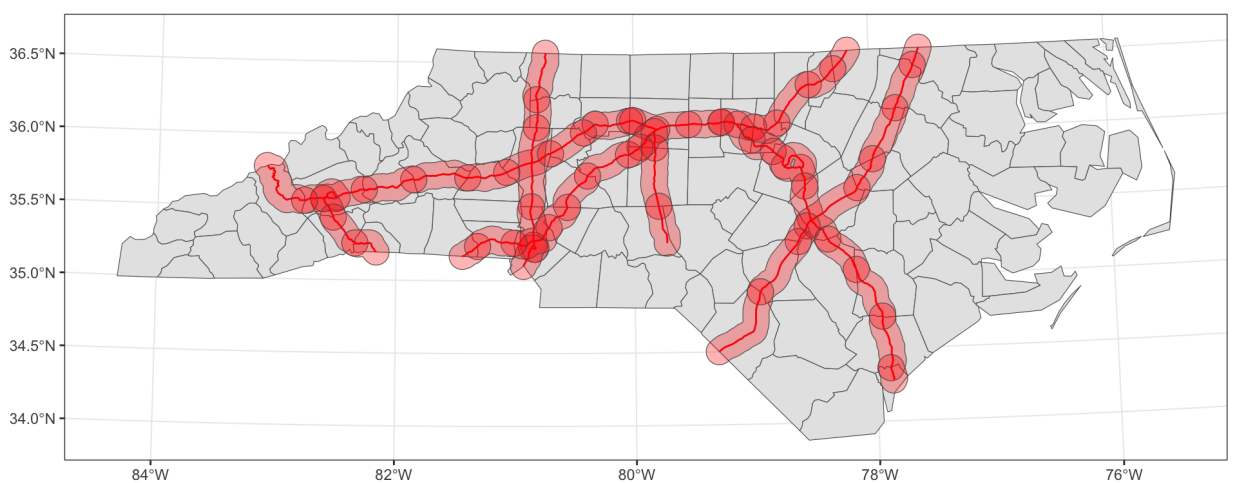
Counties near the interstate (Projection)

```
1  nc_utm  = st_transform(nc, "+proj=utm +zone=17 +datum=NAD83 +units=m +nc
2
3  ggplot() +
4    geom_sf(data=nc_utm) +
5    geom_sf(data=hwy_nc, col='red')
```



Counties near the interstate (Buffering)

```
hwy_nc_buffer = hwy_nc |>
  st_transform("+proj=utm +zone=17 +datum=NAD83 +units=m +no_defs") |>
  st_buffer(10000)

ggplot() +
  geom_sf(data=nc_utm) +
  geom_sf(data=hwy_nc, color='red') +
  geom_sf(data=hwy_nc_buffer, fill='red', alpha=0.3)
```



Counties near the interstate (Buffering + Union)

```
hwy_nc_buffer = hwy_nc |>
  st_transform("+proj=utm +zone=17 +datum=NAD83 +units=m +no_defs") |>
  st_buffer(10000) |>
  st_union() |>
  st_sf()

ggplot() +
  geom_sf(data=nc_utm) +
  geom_sf(data=hwy_nc, color='red') +
  geom_sf(data=hwy_nc_buffer, fill='red', alpha=0.3)
```

Example

How many counties in North Carolina are within 5, 10, 20, or 50 km of an interstate highway?

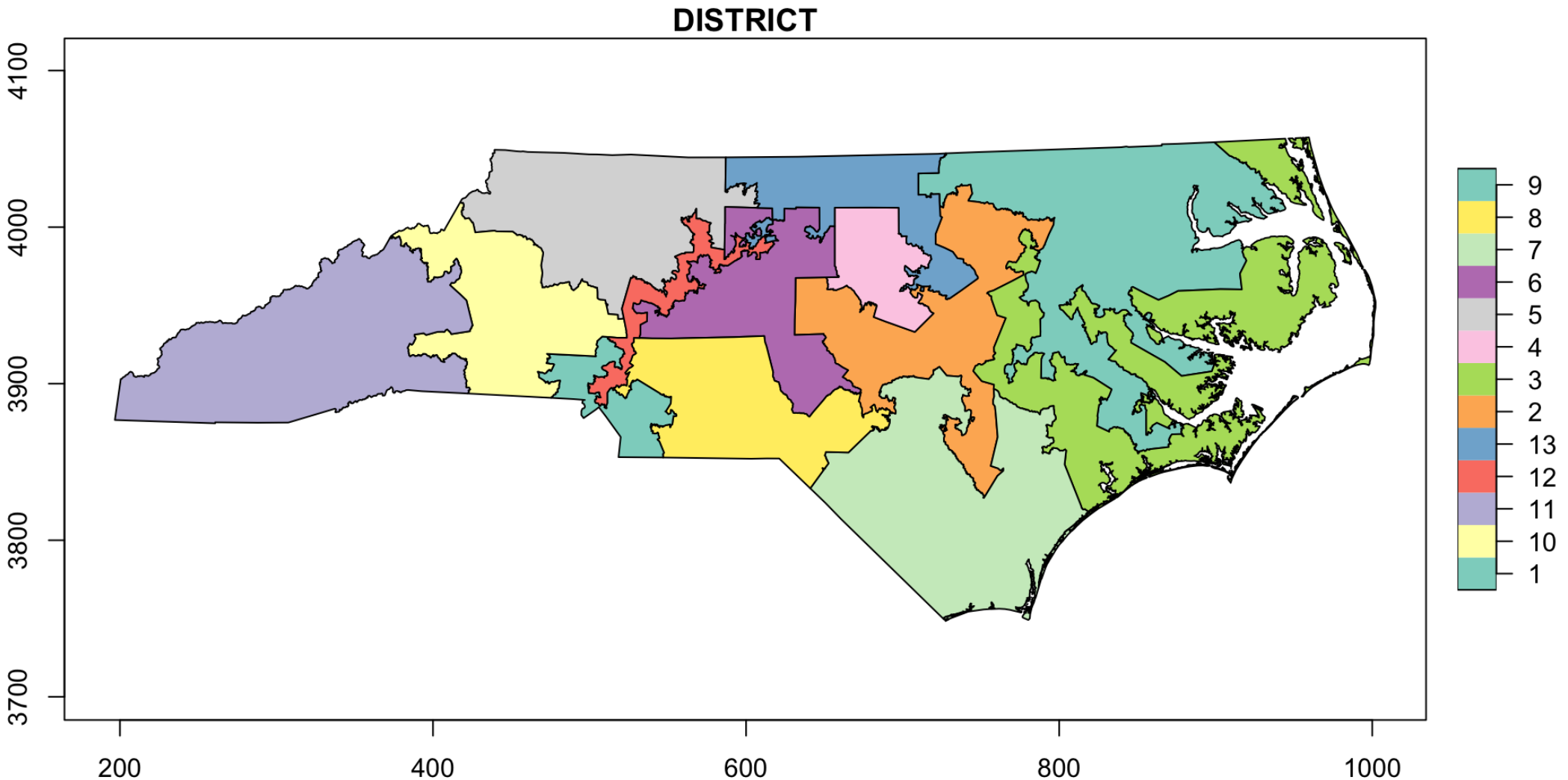
Gerrymandering Example

NC House Districts - 112th Congress

```
( nc_house = read_sf("data/nc_districts112.gpkg", quiet = TRUE) |>
    select(ID, DISTRICT) )
```

```
Simple feature collection with 13 features and 2 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -84.32187 ymin: 33.84452 xmax: -75.45998 ymax: 36.58812
Geodetic CRS:  WGS 84
# A tibble: 13 × 3
   ID           DISTRICT                                        geom
   <chr>        <chr>                                <MULTIPOLYGON [°]>
 1 037108112001 1        (((-77.32845 35.35031, -77.35398 3…
 2 037108112002 2        (((-78.89928 35.12619, -78.89763 3…
 3 037108112003 3        (((-75.68266 35.23291, -75.68113 3…
 4 037108112004 4        (((-78.77926 35.78568, -78.77947 3…
 5 037108112005 5        (((-79.8968 36.38075, -79.89213 36…
```

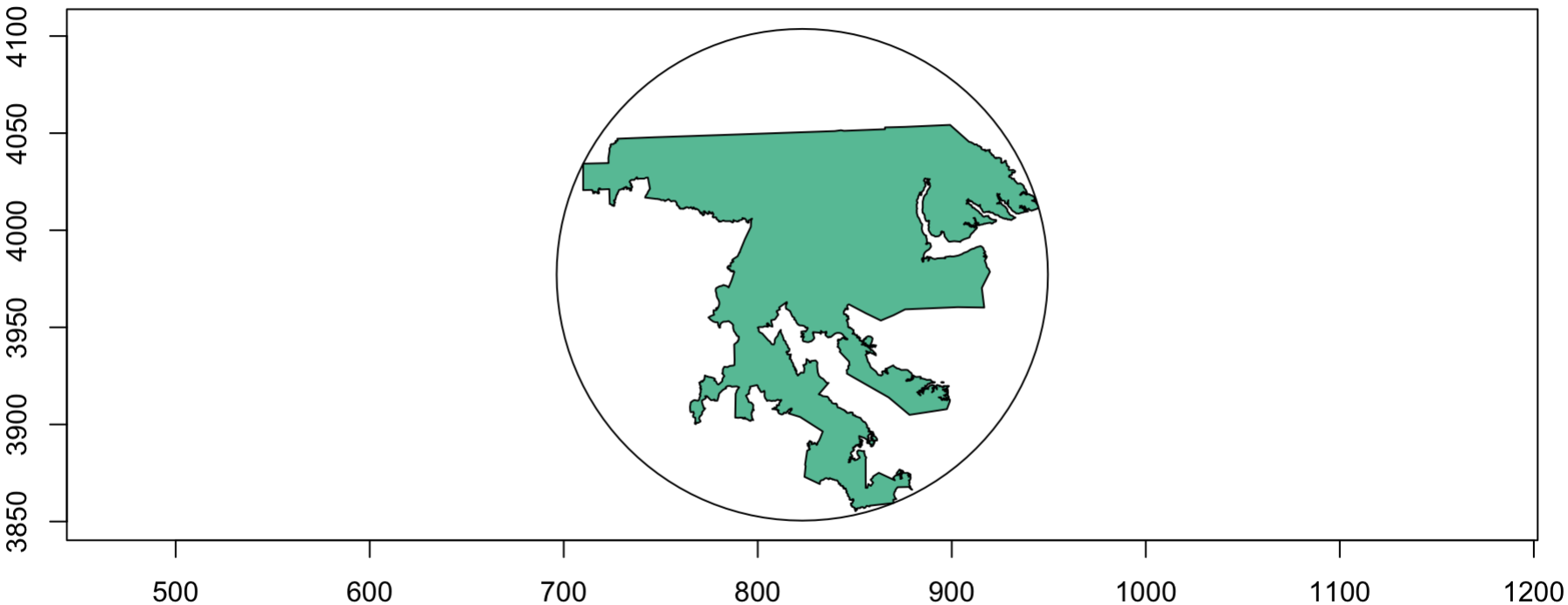
```r
nc_house = nc_house |>
  st_transform("+proj=utm +zone=17 +datum=NAD83 +units=km +no_defs")
plot(nc_house[,"DISTRICT"], axes=TRUE)
```



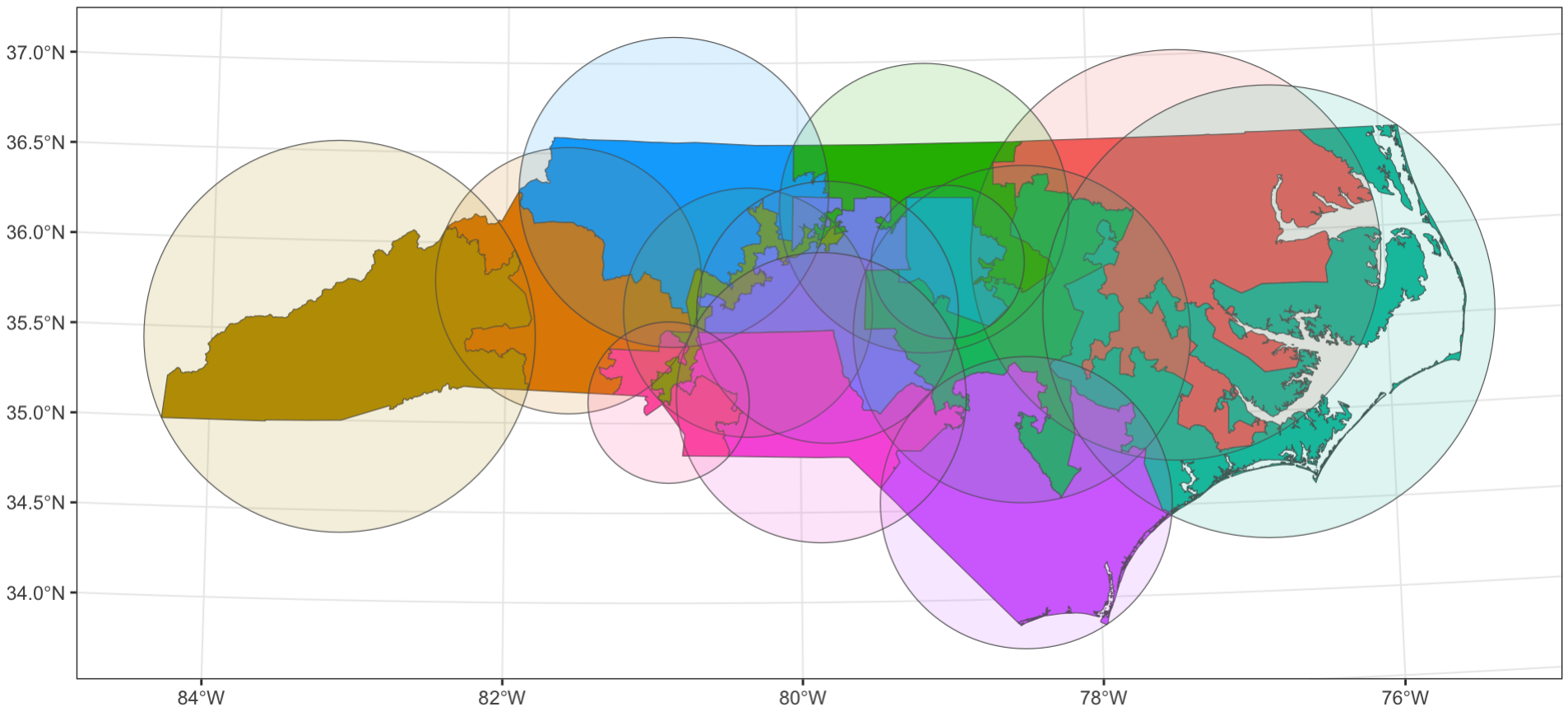
Measuring Compactness - Reock Score

The Reock score is a measure of compactness that is calculated as the the ratio area of a shape to the area of its minimum bounding circle.

```
circs = nc_house |>
  lwgeom::st_minimum_bounding_circle()

plot(circs |> filter(DISTRICT == 1) |> st_geometry(), axes=TRUE)
plot(nc_house |> select(DISTRICT) |> filter(DISTRICT == 1), add=TRUE)
```

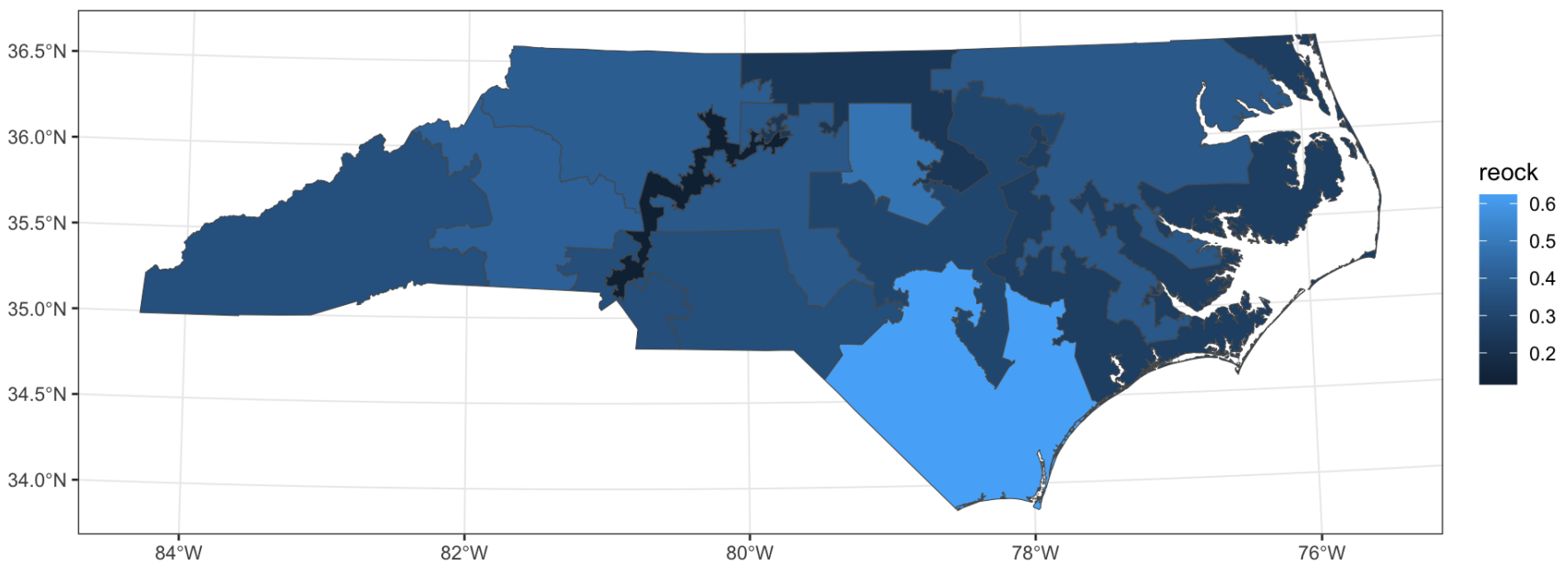

4100
4050
4000
3950
3900
3850
500
600
700
800
900
1000
1100
1200

```
ggplot(mapping = aes(fill=DISTRICT)) +
  geom_sf(data=nc_house) +
  geom_sf(data=circs, alpha=0.15) +
  guides(color="none", fill="none")
```



Calculating Reock

```
1 nc_house |>
2   mutate(reock = (st_area(nc_house) / st_area(circs)) |> as.numeric())
3   ggplot(aes(fill = reock)) +
4     geom_sf()
```



```r
nc_house |>
  mutate(reock = st_area(nc_house) / st_area(circs)) |>
  arrange(reock) |>
  print(n=13)
```

```
Simple feature collection with 13 features and 3 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: 196.7724 ymin: 3748.368 xmax: 1002.17 ymax: 4057.317
CRS:           +proj=utm +zone=17 +datum=NAD83 +units=km +no_defs
# A tibble: 13 × 4
   ID           DISTRICT                          geom reock
   <chr>        <chr>              <MULTIPOLYGON [km]>   [1]
 1 037108112012 12       (((545.2987 3945.168, 543.52… 0.116
 2 037108112013 13       (((597.9665 4026.852, 598.03… 0.237
 3 037108112003 3        (((984.0709 3911.853, 984.21… 0.266
 4 037108112002 2        (((691.4141 3889.056, 691.55… 0.303
 5 037108112009 9        (((506.3207 3893.208, 506.88… 0.339
 6 037108112008 8        (((688.6584 3870.456, 688.02… 0.342
 7 037108112011 11       (((226.7522 3918.52, 226.716… 0.344
 8 037108112006 6        (((552.4691 3949.669, 552.94… 0.378
```

Raster Data (stars)

Example data - Meuse

```r
( meuse_rast = stars::read_stars(
    system.file("external/test.grd", package="raster")
  ) |>
    st_transform(st_crs(meuse_riv))
 )
```

```
stars object with 2 dimensions and 1 attribute
attribute(s):
              Min.  1st Qu.   Median    Mean  3rd Qu.
test.grd  138.7071 293.9575 371.9001 425.606 501.0102
              Max. NA's
test.grd  1736.058 6022
dimension(s):
  from  to offset delta                refsys point
x    1  80     NA    NA Amersfoort / RD New    NA
y    1 115     NA    NA Amersfoort / RD New    NA
                     values x/y
x [80x115] 178451,...,181611 [x]
```

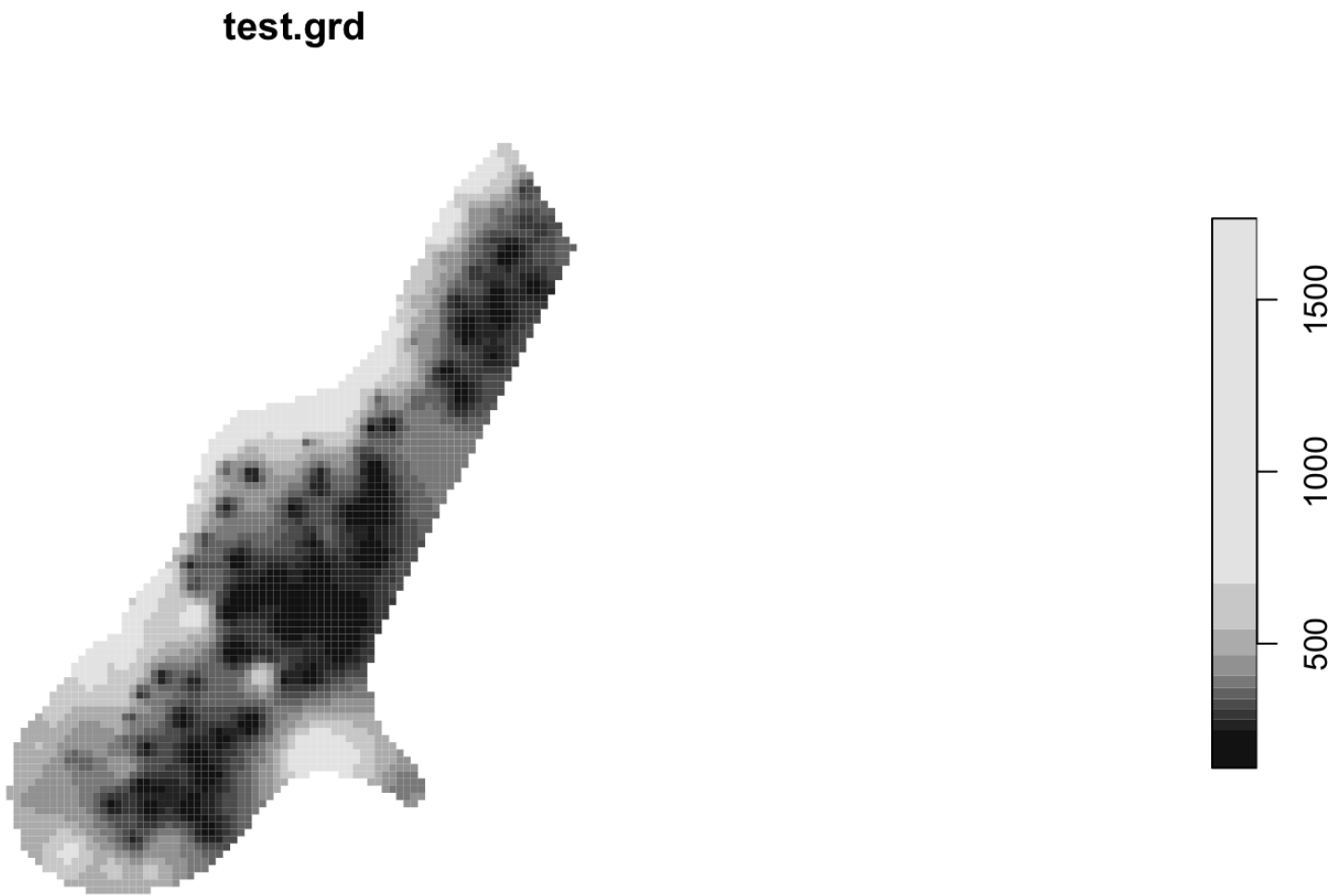
stars class

```
1 str(meuse_rast)
```

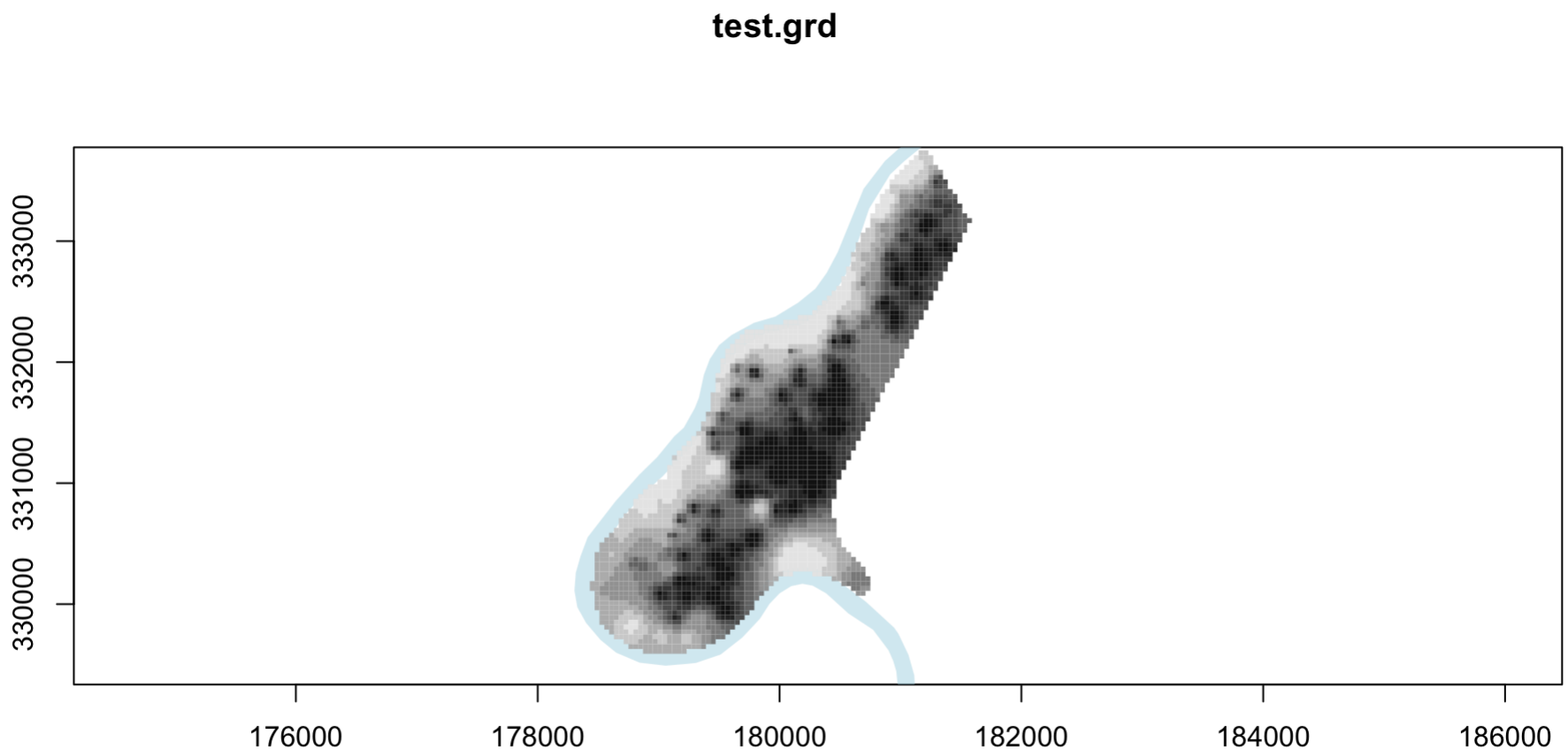
```
List of 1
 $ test.grd: num [1:80, 1:115] NA NA NA NA NA NA NA NA NA NA ...
 - attr(*, "dimensions")=List of 2
  ..$ x:List of 7
  .. ..$ from  : num 1
  .. ..$ to    : num 80
  .. ..$ offset: num NA
  .. ..$ delta : num NA
  .. ..$ refsys:List of 2
  .. .. ..$ input: chr "EPSG:28992"
  .. .. ..$ wkt  : chr "PROJCRS[\"Amersfoort / RD New\",\n    BASEGEOGCRS[\"Amersfoort\",\n
DATUM[\"Amersfoort\",\n            E"| __truncated__
  .. .. ..- attr(*, "class")= chr "crs"
  .. ..$ point : logi NA
  .. ..$ values: num [1:80, 1:115] 178451 178491 178531 178571 178611 ...
  .. ..- attr(*, "class")= chr "dimension"
```

Plotting

```
1  plot(meuse_rast)
```

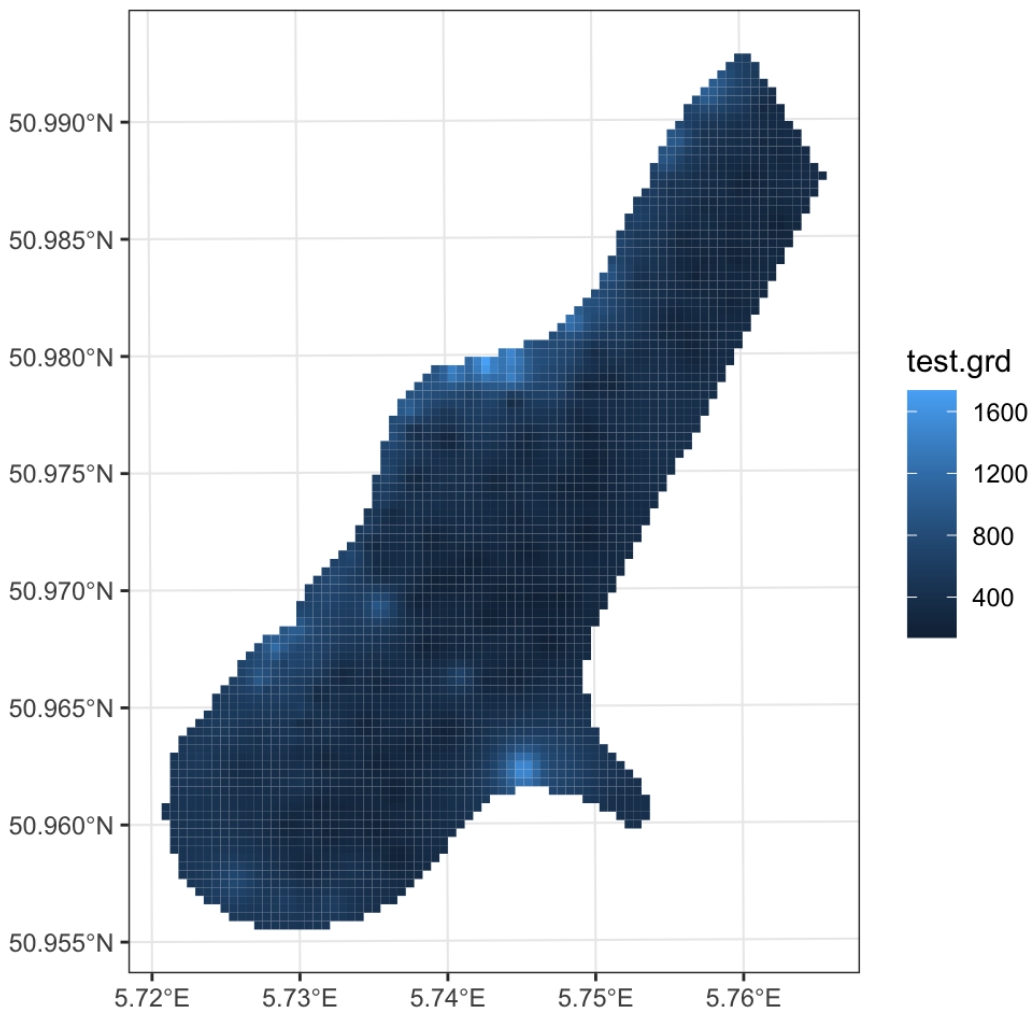


```r
plot(
  meuse_riv,
  col=adjustcolor("lightblue",alpha.f = 0.5), border=NA,
  ylim = c(329500, 333611), axes=TRUE
)
plot(meuse_rast, add=TRUE)
```

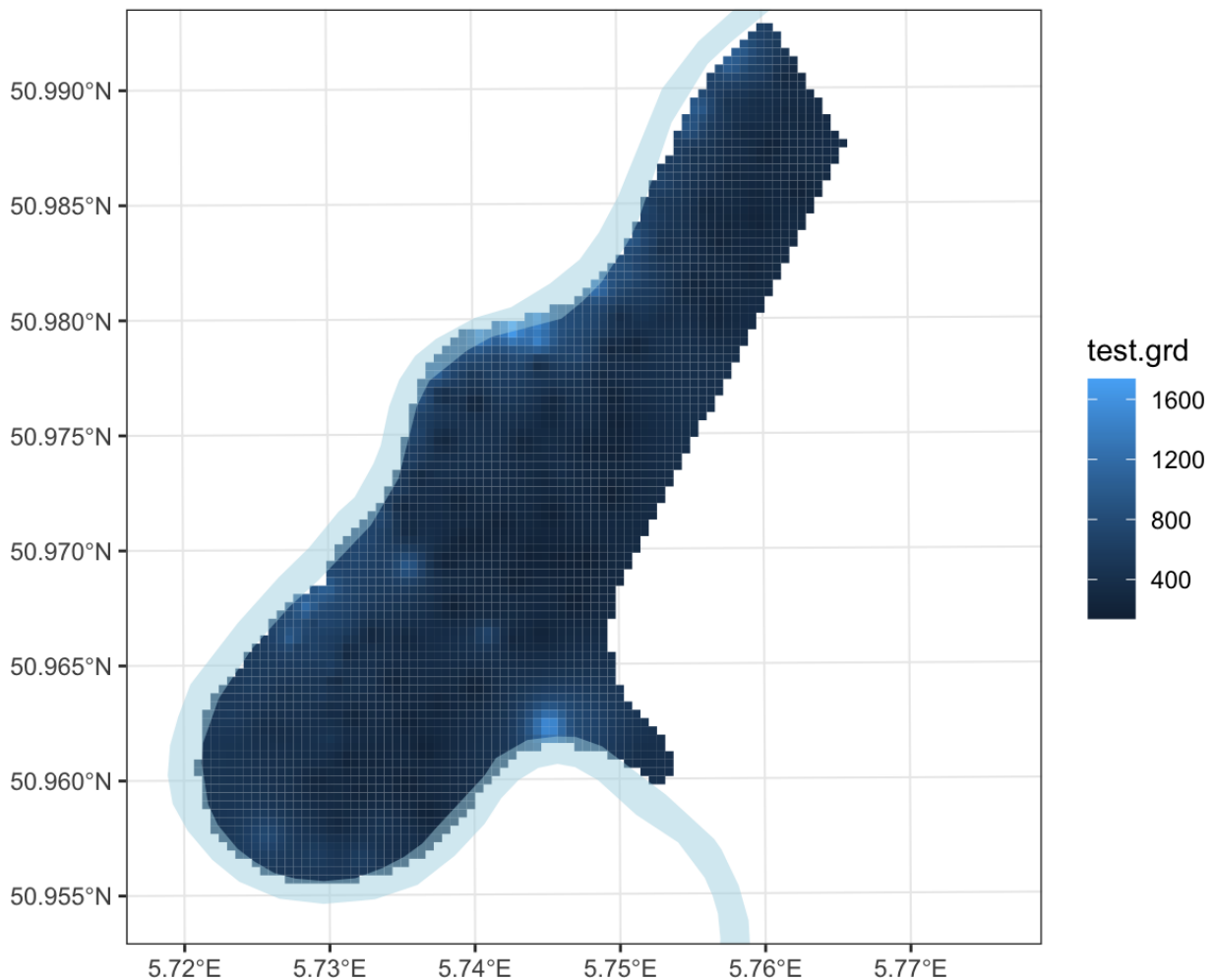


ggplot

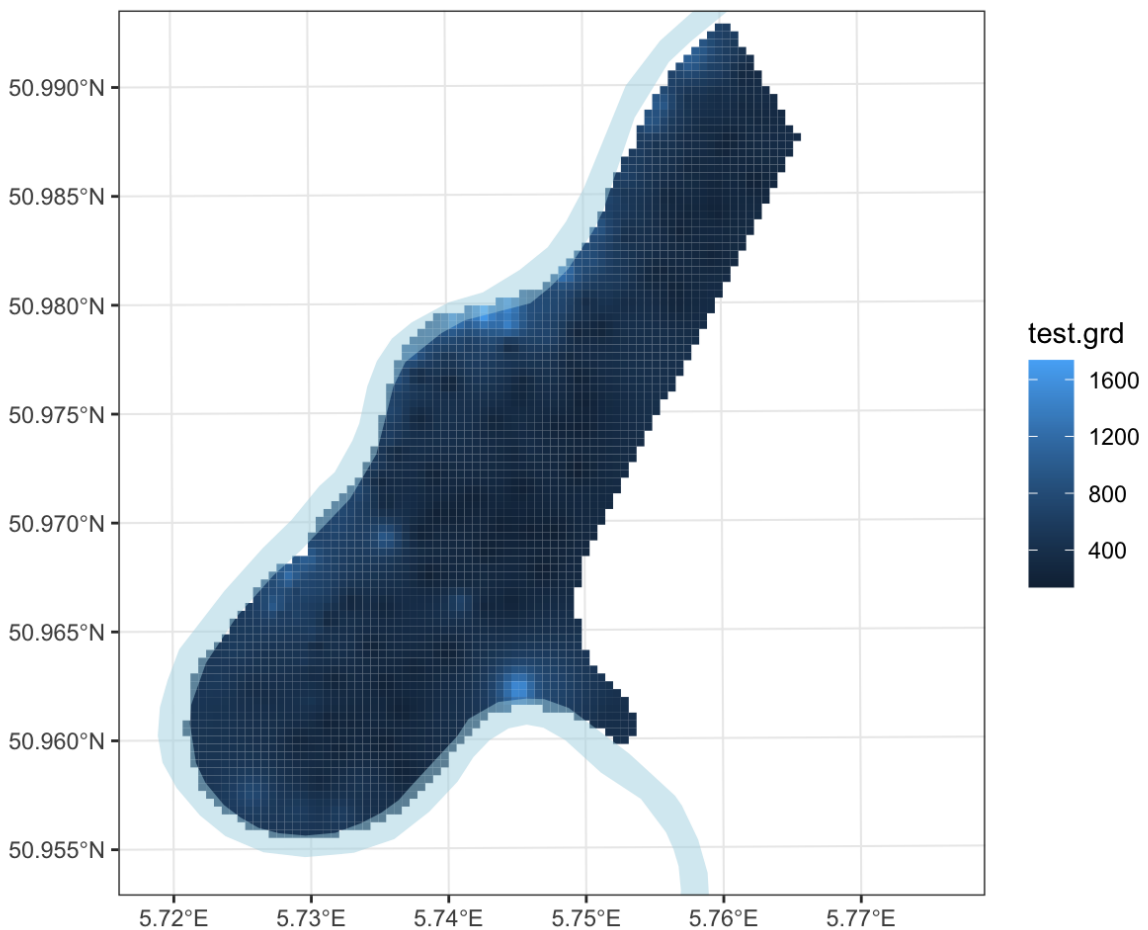
```
1  ggplot() +
2    stars::geom_stars(data=meuse_rast)
```



```
ggplot() +
  stars::geom_stars(data=meuse_rast) +
  geom_sf(data=meuse_riv, fill="lightblue", color=NA, alpha=0.5) +
  ylim(329500, 333611)
```



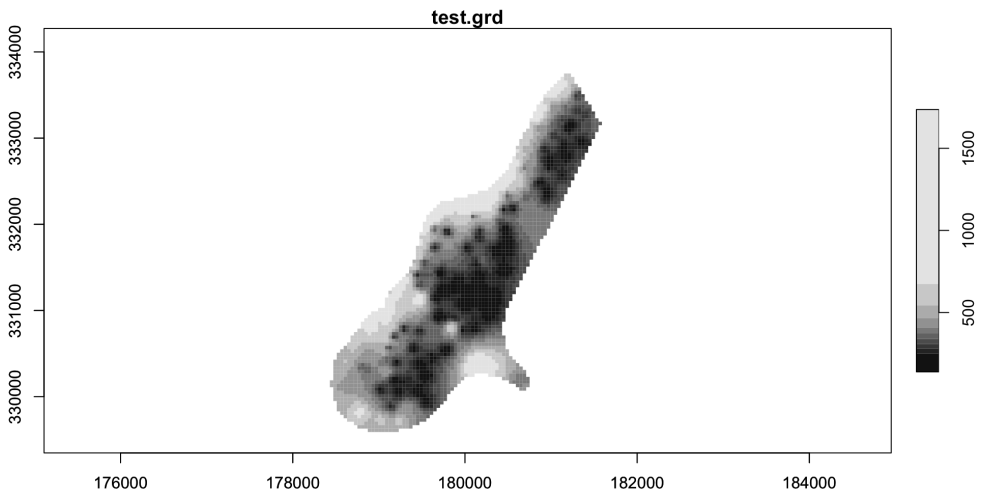
```
ggplot() +
  stars::geom_stars(data=meuse_rast) +
  geom_sf(data=meuse_riv, fill="lightblue", color=NA, alpha=0.5) +
  ylim(329500, 333611) +
  scale_fill_gradient(na.value = NA)
```



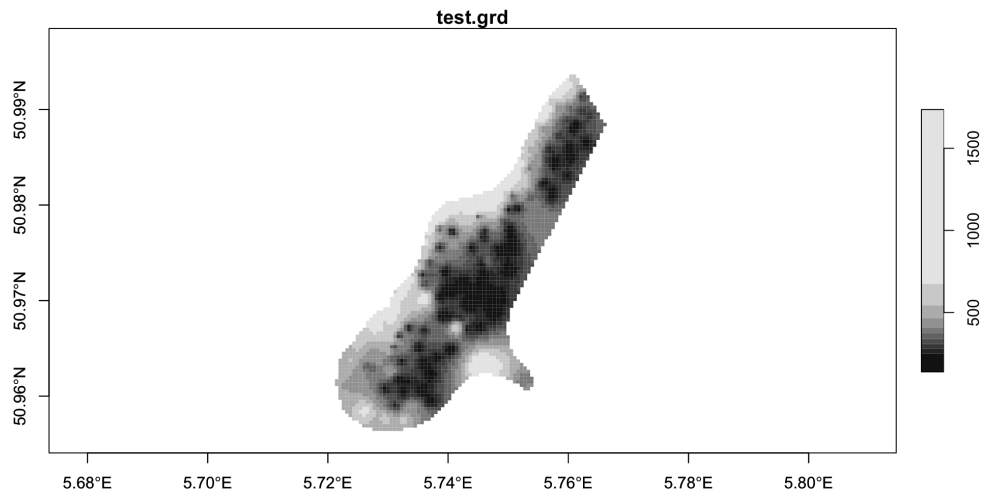
Rasters and Projections

```
1 meuse_rast_ll = st_transform(meuse_rast, "+proj=longlat +datum=NAD83 +no_defs")
```

```
1 plot(meuse_rast, axes=TRUE)
```




```
1 plot(meuse_rast_ll, axes=TRUE)
```



```
1 meuse_rast
```

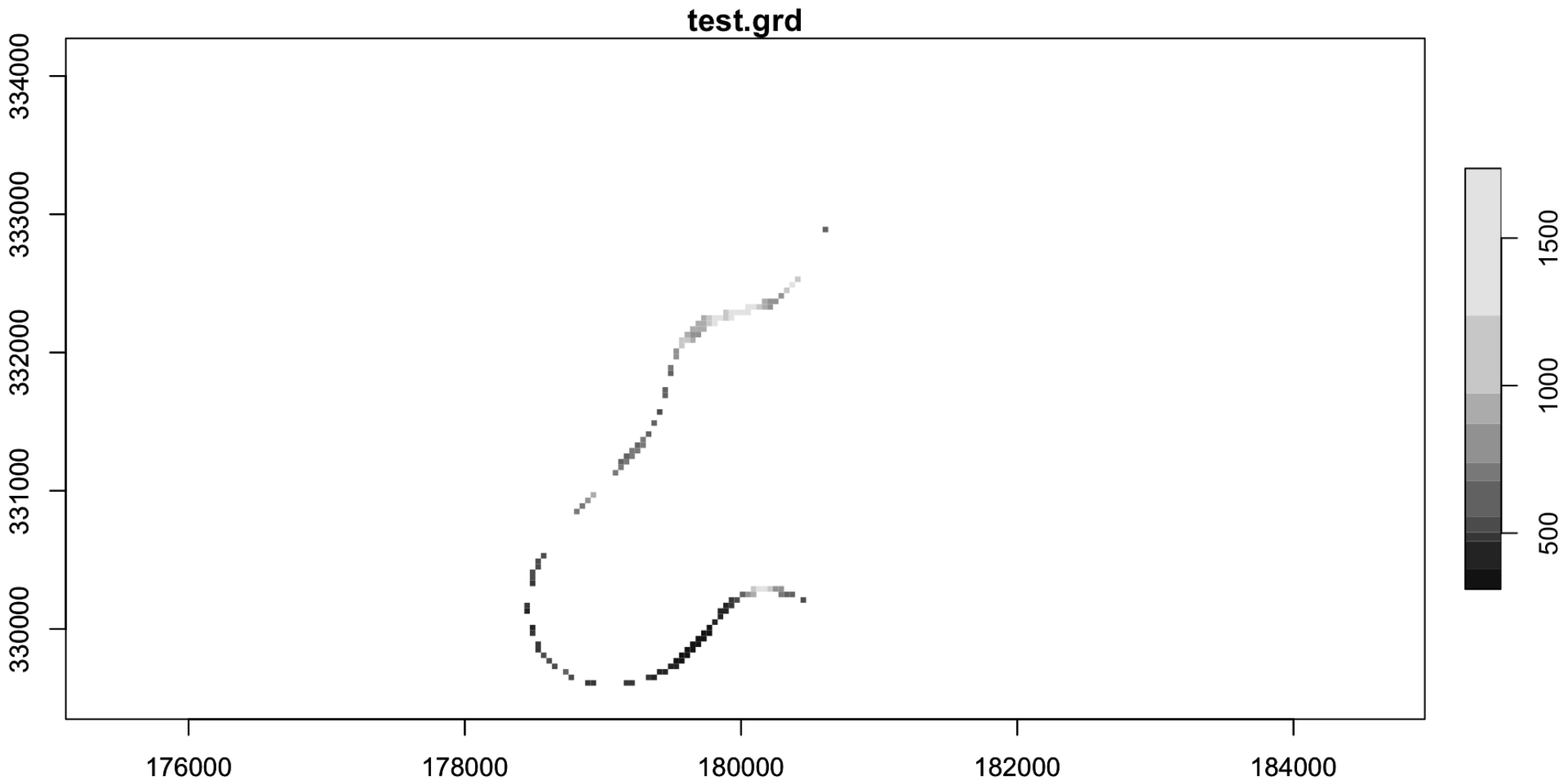
```
stars object with 2 dimensions and 1 attribute
attribute(s):
              Min.  1st Qu.   Median    Mean
3rd Qu.
test.grd  138.7071 293.9575 371.9001 425.606
501.0102
              Max. NA's
test.grd  1736.058 6022
dimension(s):
  from  to offset delta              refsys
point
x    1  80     NA    NA Amersfoort / RD New
NA
y    1 115     NA    NA Amersfoort / RD New
NA
                     values x/y
```

```
1 meuse_rast_ll
```

```
stars object with 2 dimensions and 1 attribute
attribute(s):
              Min.  1st Qu.   Median    Mean
3rd Qu.
test.grd  138.7071 293.9575 371.9001 425.606
501.0102
              Max. NA's
test.grd  1736.058 6022
dimension(s):
  from  to offset delta
refsys point
x    1  80     NA    NA +proj=longlat
+datum=NAD8...    NA
y    1 115     NA    NA +proj=longlat
+datum=NAD8...    NA
                         values x/y
```

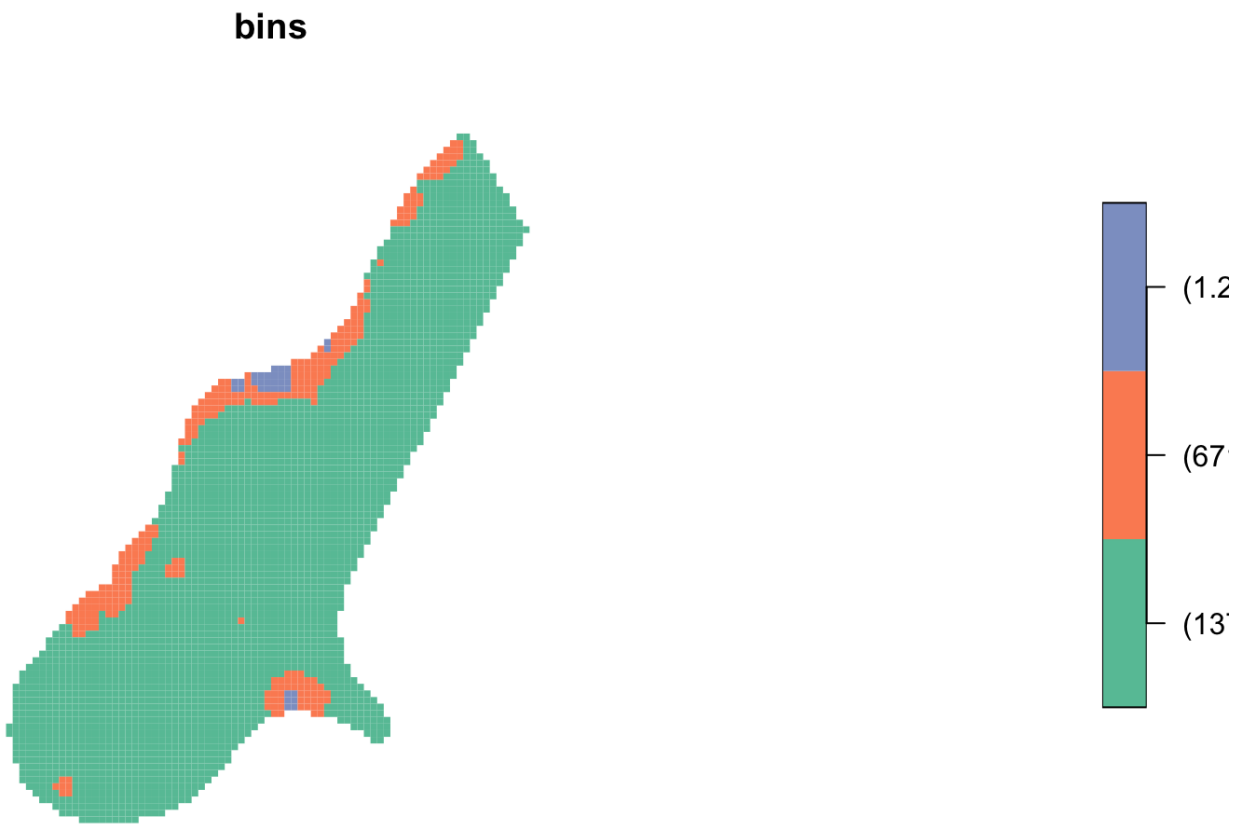
Cropping

```
1 meuse_rast_riv = meuse_rast[ meuse_riv ]
2 plot(meuse_rast_riv, axes=TRUE)
```



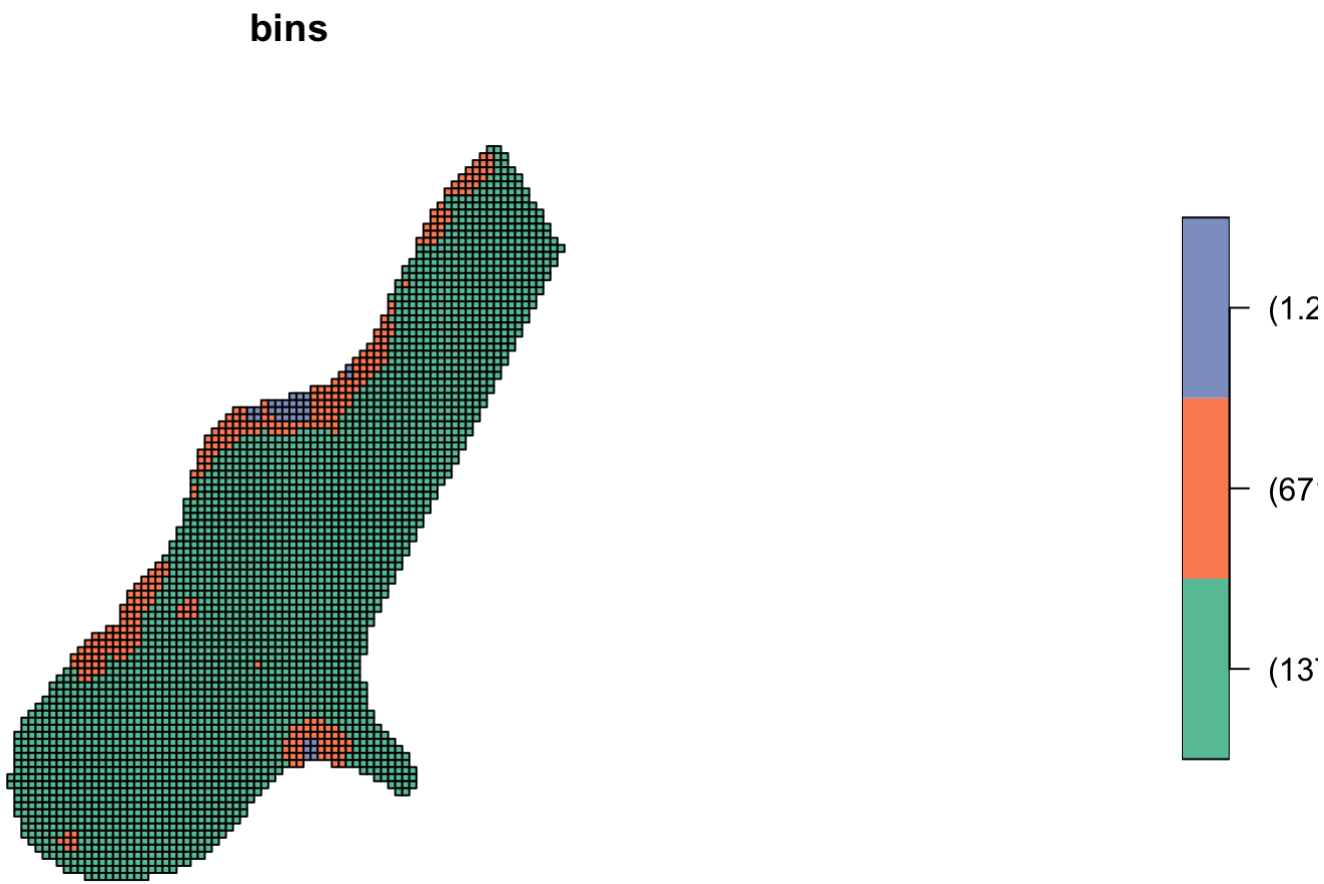
Segmentation

```
1 meuse_rast |>
2   mutate(bins = cut(test.grd, 3) ) |>
3   select(bins) |>
4   plot()
```

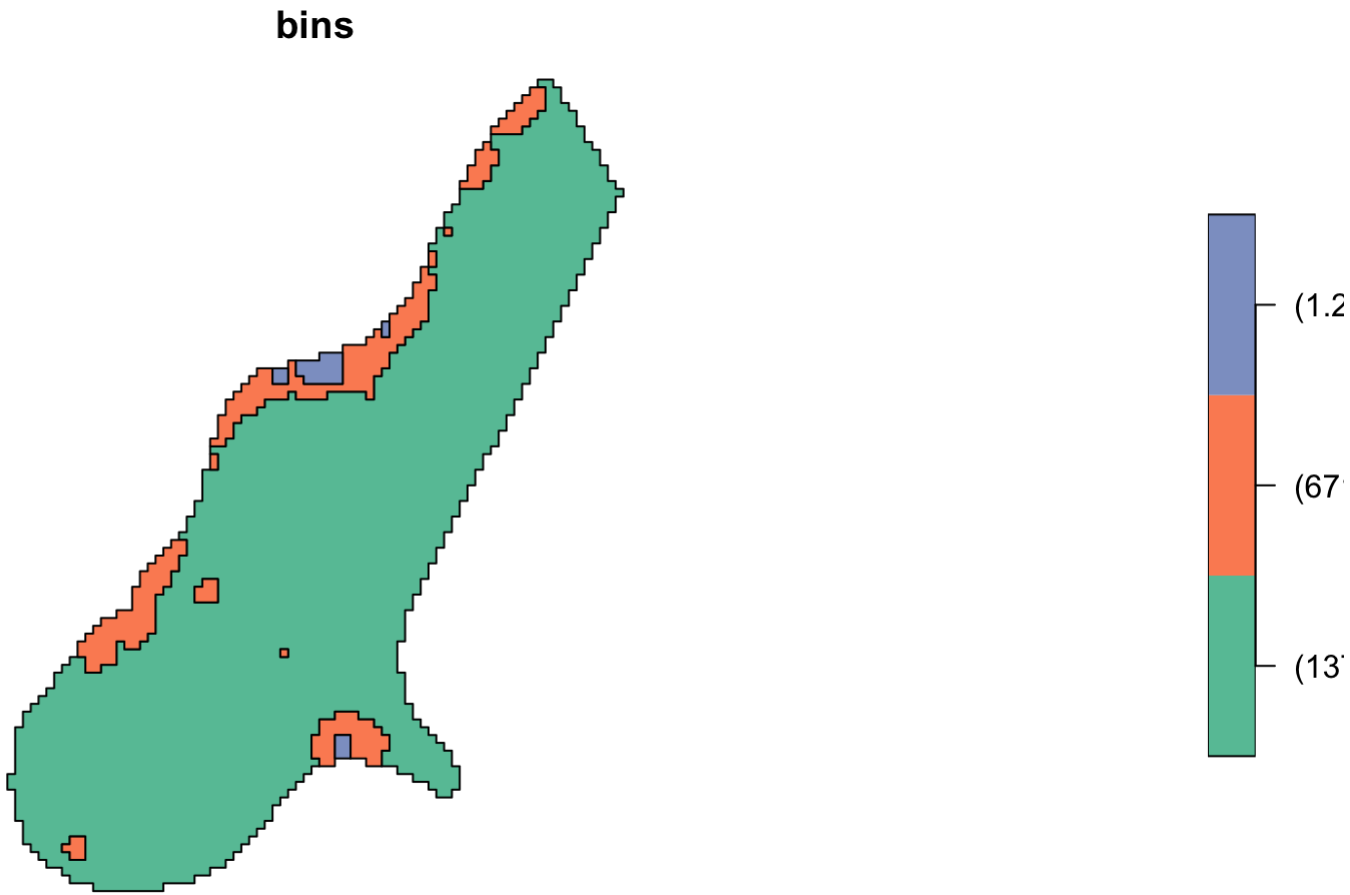


Polygonization

```
meuse_rast_poly = meuse_rast |>
  mutate(bins = cut(test.grd, 3) ) |>
  select(bins) |>
  st_as_sf()
plot(meuse_rast_poly)
```



```
meuse_rast_poly |>
  group_by(bins) |>
  summarize() |>
  plot()
```



```r
meuse_rast_poly |>
  group_by(bins) |>
  summarize() |>
  mutate(area = st_area(geometry))
```

```
Simple feature collection with 3 features and 2 fields
Geometry type: GEOMETRY
Dimension:     XY
Bounding box:  xmin: 178431 ymin: 329589.8 xmax: 181590.9 ymax: 333749.8
Projected CRS: Amersfoort / RD New
# A tibble: 3 × 3
  bins                                    geometry   area
* <fct>                                <GEOMETRY [m]>  [m^2]
1 (137,671]           POLYGON ((178551 329829.8, 1785… 4.56e6
2 (671,1.2e+03]       MULTIPOLYGON (((178711 329829.8… 4.74e5
3 (1.2e+03,1.74e+03] MULTIPOLYGON (((179790.9 332189… 5.12e4
```