Creating maps in R - basics

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Exercise 1: Create study area map using "ggplot"

All datasets are found in the "data"-folder.

Here, we use the package 'rnaturalearth' to download countries in a ESRI shapefile format. These are available for download here: https://www.naturalearthdata.com/downloads/10m-cultural-vectors/10m-admin-0-countries/

Coordinate reference systems (CRS)
CRS provide a standardized way of describing locations to describe geographic data. The CRS that is chosen depends on when the data was collected, the purpose of the data, etc. It is necessary to transform vector and raster data to a common CRS when data with different CRS are combined.

Setting CRS to SWEREF99 (Sweden). CRS can be referenced by its:

1. EPSG code, CRS("+init=epsg:3006") (see http://www.epsg-registry.org/ and http://spatialreference.org/) or by
2. proj4spring; "+proj=utm +zone=33 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs"

There are two general options:

1. unprojected (a.k.a. Geographic): Latitude/Longitude for referencing location on the ellipsoid Earth (wgs84), and
2. projected: Easting/Northing for referencing location on 2D representations of Earth (the creation of maps) e.g., SWEREF99.

More reading:
https://www.nceas.ucsb.edu/sites/default/files/2020-04/OverviewCoordinateReferenceSystems.pdf

Load vector data

How to download using "rnaturalearth" and save the shp locally

I will open the saved .shp for the exercise:

```
## load country boarders -----------


#' downladed and saved from rnaturalearth (above)
swe_no_sweref <-  input_vector %>%
```

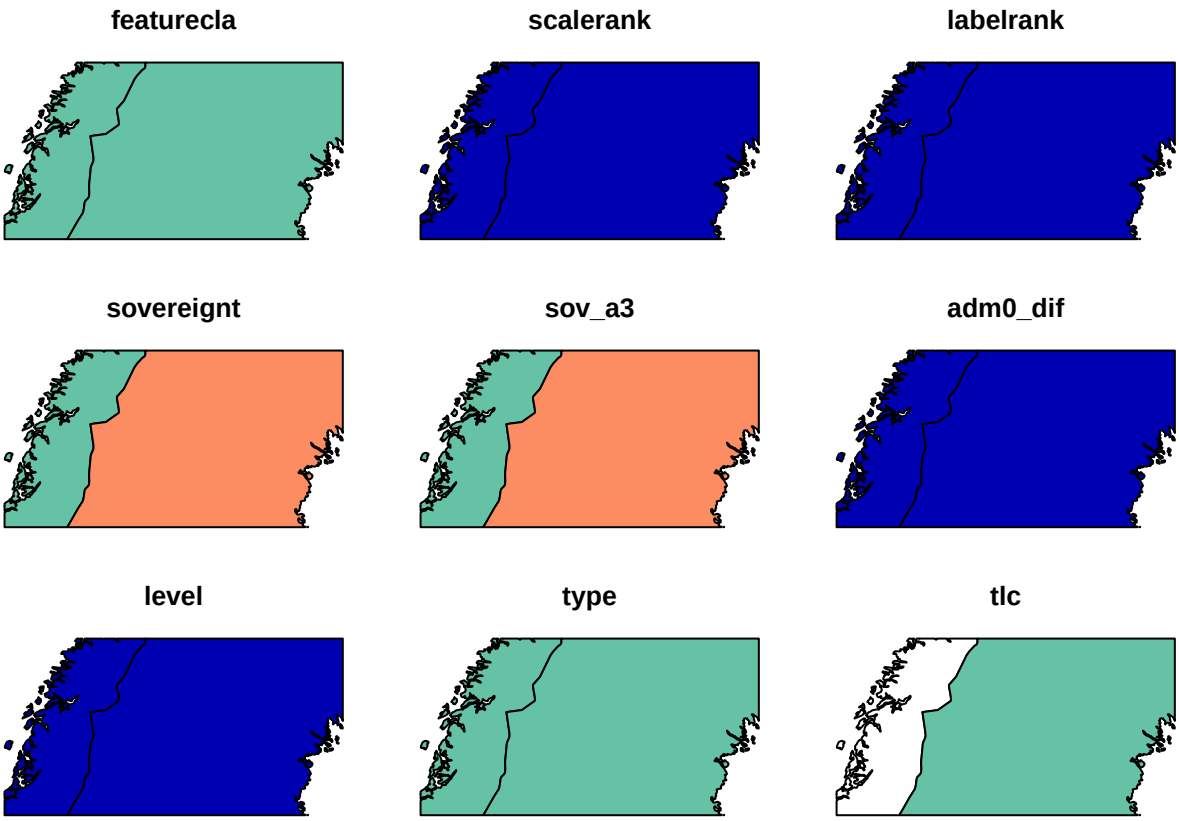
```
  # value = T: return vector containing the matching elements
  grep(pattern = "swe_no", value = T) %>%

  # read ESRI Shapefile object
  sf::st_read() %>%

  #convert geometry object into an sf object
  st_as_sf()
```

```
## Reading layer ‘swe_no’ from data source
##   ‘/Users/hirn0001/Library/CloudStorage/OneDrive-Sverigeslantbruksuniversitet/Undervisning/Teaching a
##   using driver ‘ESRI Shapefile’
## Simple feature collection with 2 features and 168 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -362704.5 ymin: -6097519 xmax: 1114145 ymax: 8972413
## Projected CRS: SWEREF99 TM
```

```
# check coordinate system
st_crs(swe_no_sweref)$proj4string
```

```
## [1] "+proj=utm +zone=33 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs"
```

```
# Create a bounding box as an sf object for layers ----
b_box <- c(xmin = 350432, ymin = 7179284,
           xmax = 857780, ymax =7444230)

#' Select the area of interest:
#' intersect the full world's coastline with the bounding box
suppressWarnings({
sweden.c <- st_crop(swe_no_sweref, b_box)
plot(sweden.c)
})
```




```
class(sweden.c)
```

```
## [1] "sf"         "data.frame"
```

```
### Load vector data

# import lakes
lakes <-  input_vector %>%
  grep(pattern = "lakes", value = T) %>%
  sf::st_read() %>%
  st_as_sf()
```

```
## Reading layer `ne_10m_lakes' from data source
##   `/Users/hirn0001/Library/CloudStorage/OneDrive-Sverigeslantbruksuniversitet/Undervisning/Teaching a
##   using driver `ESRI Shapefile'
## Simple feature collection with 1355 features and 41 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -165.9656 ymin: -50.66967 xmax: 177.1544 ymax: 81.95521
## Geodetic CRS:  WGS 84
```

```
# info about the vector
class(lakes)
```

```
## [1] "sf"         "data.frame"
```

```r
st_crs(lakes)
```

```
## Coordinate Reference System:
##   User input: WGS 84
##   wkt:
## GEOGCRS["WGS 84",
##     DATUM["World Geodetic System 1984",
##         ELLIPSOID["WGS 84",6378137,298.257223563,
##             LENGTHUNIT["metre",1]]],
##     PRIMEM["Greenwich",0,
##         ANGLEUNIT["degree",0.0174532925199433]],
##     CS[ellipsoidal,2],
##         AXIS["latitude",north,
##             ORDER[1],
##             ANGLEUNIT["degree",0.0174532925199433]],
##         AXIS["longitude",east,
##             ORDER[2],
##             ANGLEUNIT["degree",0.0174532925199433]],
##     ID["EPSG",4326]]
```

```r
# Transform or convert coordinates of simple feature (sf)
lakes <- st_transform(lakes, crs = 3006)

# crop an sf object to a specific rectangle (here based on extent of "sweden.c"-shp)
# sf_use_s2(FALSE) # use if errors occur below
lakes <- st_crop(lakes, sweden.c)
```

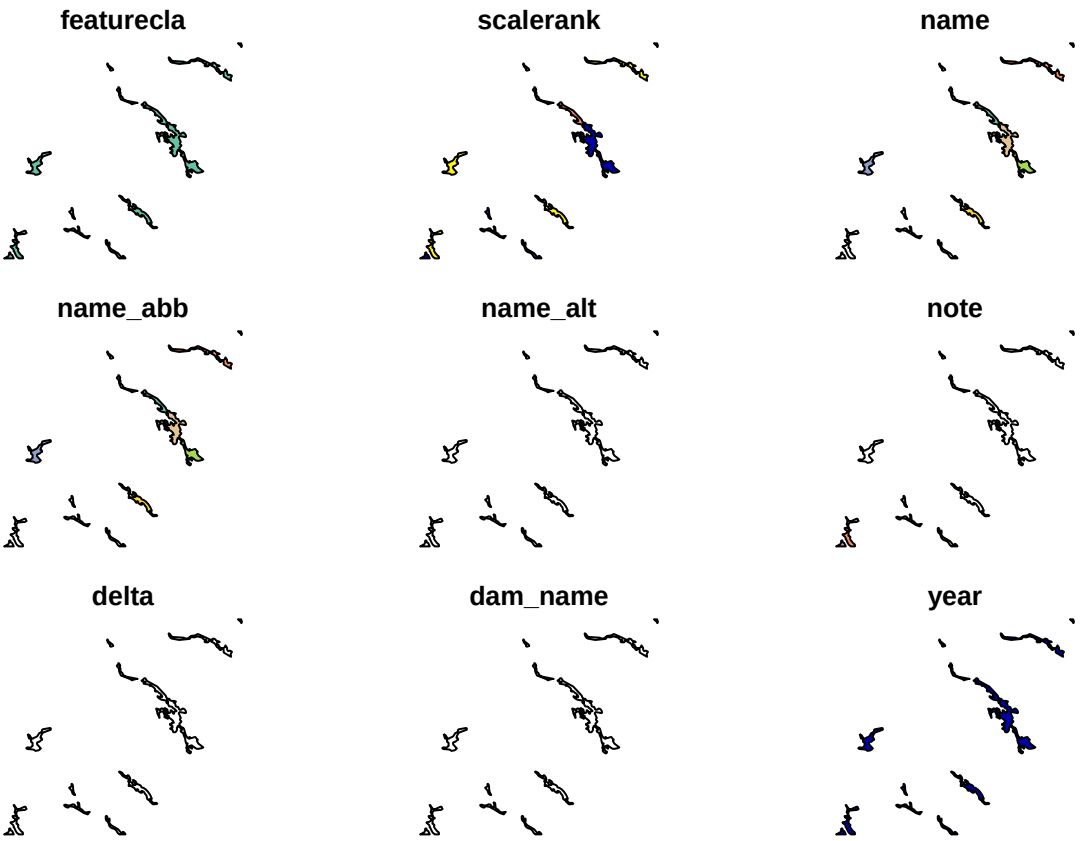
```
## Warning: attribute variables are assumed to be spatially constant throughout
## all geometries
```

```r
class(lakes)
```

```
## [1] "sf"         "data.frame"
```

```r
plot(lakes)
```

```
## Warning: plotting the first 9 out of 41 attributes; use max.plot = 41 to plot
## all
```



Add points of interest (cities)

Create xy points with labels. Here creating sf-object and setting the crs.

```
# Create points of interest (coordinates from QGIS or google maps for demonstration)
places <- data.frame(ID= c("Arjeplog", "Arvidsjaur", "Sorsele"),
                     y = c(7328407.945, 7280856.153, 7270326.684),
                     x = c(630040.101, 693262.414, 617477.638)) %>%
  st_as_sf(coords = c("x", "y"),  # create sf object
           crs=st_crs(sweden.c))  # set same crs as for sweden.c
class(places)
```

```
## [1] "sf"         "data.frame"
```

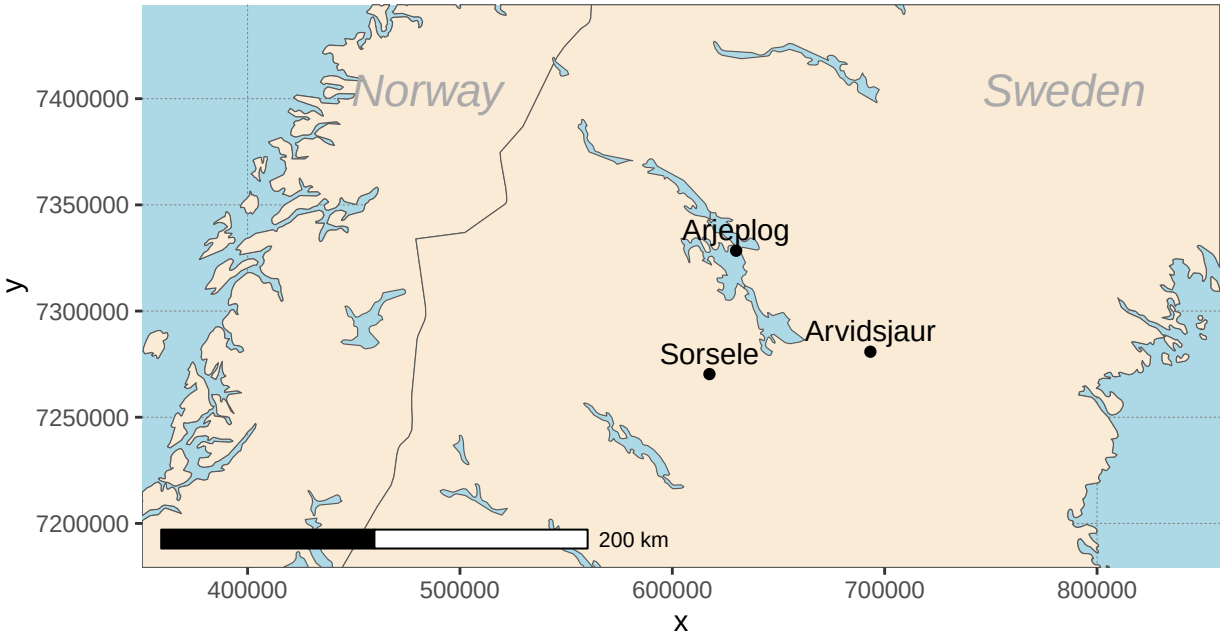
```
# st_crs(places) # check projection
```

Make plot using ggplot

```
library(ggspatial)

ggplot() +

    # plot sweden and lakes
```

```
  geom_sf(aes(geometry = sweden.c$geometry)) + # geom_sf() for vector data

  geom_sf(data = sweden.c,                     # plot sweden border vector
        aes(geometry = sweden.c$geometry),
        fill= "antiquewhite")+

    geom_sf(data = lakes,                      # plot lakes vector
            fill="lightblue") +

# layer_spatial(data=elevation) +

# add cities
geom_sf(data = places) +

# add city names
geom_sf_text(data = places, aes(label = ID),
             vjust=-0.5)+

# Add text on map
annotate(geom = "text",
           x = 484609, y = 7404230,
           label = "Norway",
           fontface = "italic",
           color = "darkgray",
         size = 6) +

  annotate(geom = "text",
           x = 784609, y = 7404230,
           label = "Sweden",
           fontface = "italic",
           color = "darkgray",
         size = 6) +

# Add north arrow
annotation_north_arrow(location = "bl",
                       which_north = "true",
                         height = unit(1, "cm"),
width = unit(1, "cm"),
                       pad_x = unit(0.5, "cm"), # horizontal align
                       pad_y = unit(8, "cm"), # vertical align
                       style = north_arrow_fancy_orienteering) +
#add annotation scale
annotation_scale(location = "bl",
                   width_hint = 0.5) +


# keep new projection for ggplot
coord_sf(crs = st_crs(3006),
datum = sf::st_crs(3006),
expand = FALSE) +

# add grid lines
theme(panel.grid.major = element_line(color = gray(.5),
```

```
                                        linetype = "dashed",
                                        linewidth  = 0.1),
        panel.background = element_rect(fill = "lightblue"))
```




```
### examplefor removing or adding titles
# theme(axis.title.x = element_blank(),     # remove
#       axis.title.y = element_blank()) +
  # xlab("Longitude") + ylab("Latitude")    # add

#save plot
ggsave("output_data/Fig1_study_area.png", width = 8, height = 6, dpi = 400)
```

Optional: Create a polygon and add to map

Exercise 2: Maps in R

Pre-define crs using ESPG-code or proj4string by:

- ESPG: CRS("+init=epsg:3006")
- proj4string: "+proj=utm +zone=33 +ellps=GRS80 +units=m +no_defs"

```
# projection to use; here by using proj4string
crs_to_use <- "+proj=utm +zone=33 +ellps=GRS80 +units=m +no_defs"
```

Load background data

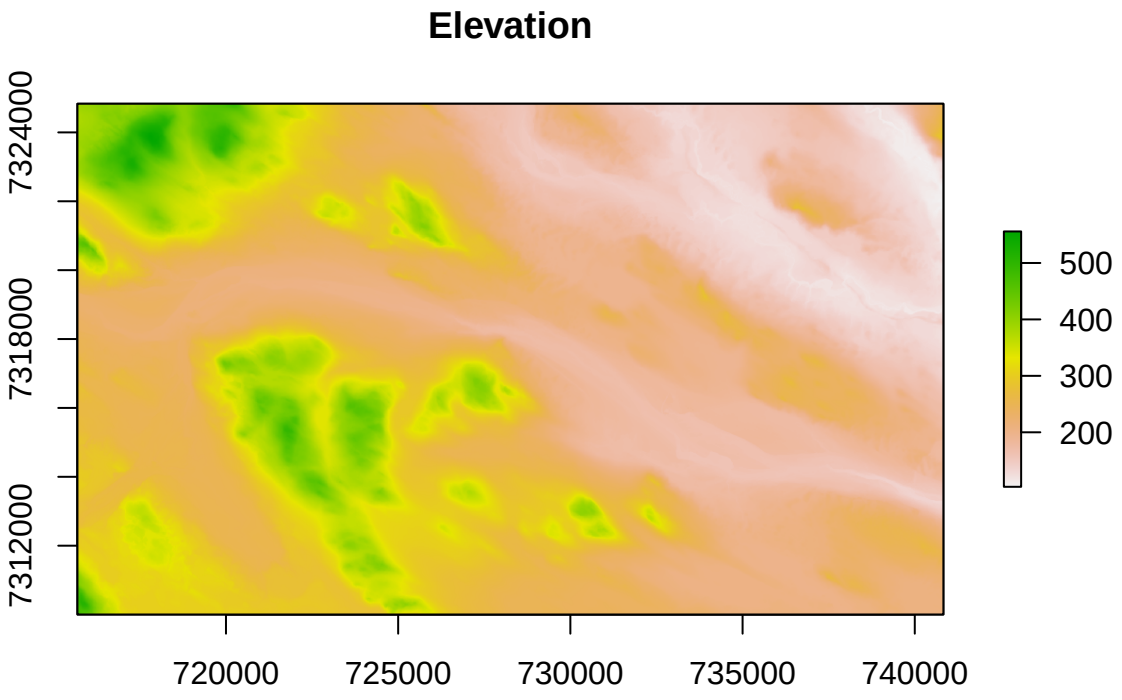
Now let's start by loading the maps using the "raster"-package.

Another option: "terra"-package using rast()-function)

```
## [1] "input_data/raster/PV_2021_cc.tif"
## [2] "input_data/raster/PV_2021_dem.tif"
## [3] "input_data/raster/PV_2021_houses.tif"
## [4] "input_data/raster/PV_2021_lichen.tif"
## [5] "input_data/raster/PV_2021_nmd.tif"
## [6] "input_data/raster/PV_2021_roads.tif"
## [7] "input_data/raster/PV_2021_slope.tif"
## [8] "input_data/raster/PV_2021_TRI.tif"
```

```
## [1] "Clear_cuts_2021"             "PV_2021_dem"
## [3] "prox10_houses_stakke"        "lichenmap_stakke_original"
## [5] "nmd10_stakke_ungeneralized" "prox10_stakke_resample"
## [7] "slope10m_QGIS"               "ruggedness10_QGIS"
```

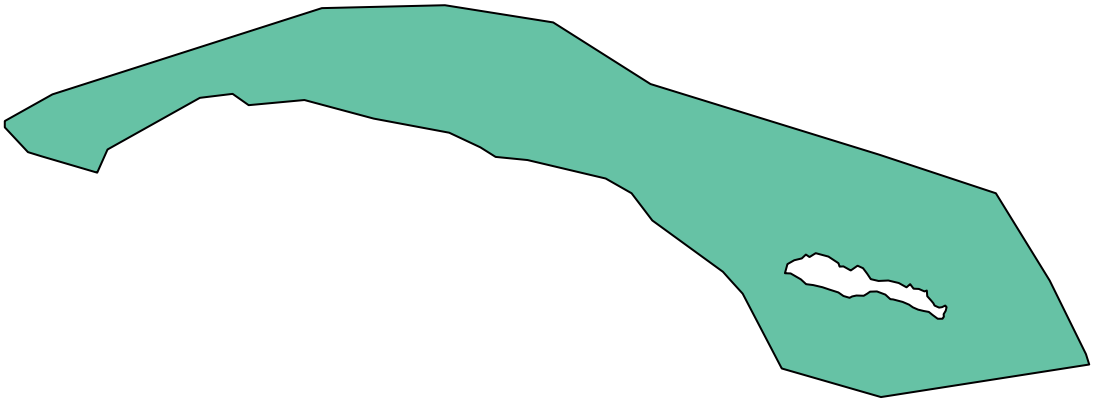
```
## [1] "+proj=utm +zone=33 +ellps=GRS80 +units=m +no_defs"
```



```
## Reading layer ‘spatial_files_availability_PV_winter_2021_shorter_modified_new’ from data source ‘/Us
##   using driver ‘ESRI Shapefile’
## Simple feature collection with 1 feature and 3 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: 716285.4 ymin: 7313268 xmax: 739293.8 ymax: 7321582
## Projected CRS: SWEREF99 TM
```

```
## [1] "+proj=utm +zone=33 +ellps=GRS80 +units=m +no_defs"
```

Home range



Add animal data (GPS points)

Load prepared reindeer data

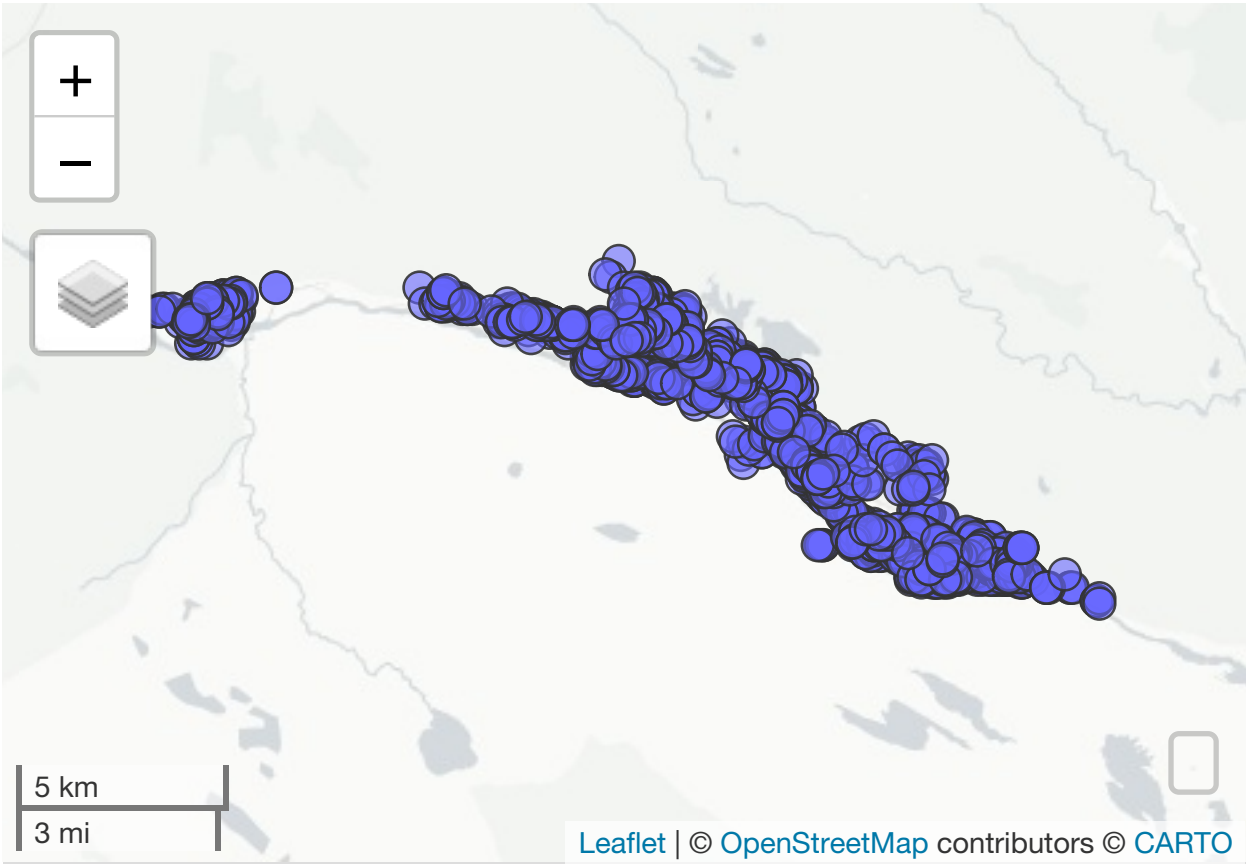
```
##    Collar_ID           id year       x_      y_                  t_ group
## 1 FIT_421952 rt_PV_20_020 2021 733705.8 7314782 2021-01-28 08:01:13   Fed
## 2 FIT_421952 rt_PV_20_020 2021 733653.5 7314737 2021-01-28 12:00:50   Fed
## 3 FIT_421952 rt_PV_20_020 2021 733836.3 7314807 2021-01-28 16:00:41   Fed
## 4 FIT_421952 rt_PV_20_020 2021 733828.4 7314851 2021-01-28 20:00:44   Fed
## 5 FIT_421952 rt_PV_20_020 2021 733682.5 7314738 2021-01-29 00:01:04   Fed
## 6 FIT_421952 rt_PV_20_020 2021 733320.5 7315244 2021-02-01 00:00:41   Fed
```

```
## 'data.frame':    5951 obs. of  7 variables:
##  $ Collar_ID: chr  "FIT_421952" "FIT_421952" "FIT_421952" "FIT_421952" ...
##  $ id       : chr  "rt_PV_20_020" "rt_PV_20_020" "rt_PV_20_020" "rt_PV_20_020" ...
##  $ year     : int  2021 2021 2021 2021 2021 2021 2021 2021 2021 2021 ...
##  $ x_       : num  733706 733653 733836 733828 733683 ...
##  $ y_       : num  7314782 7314737 7314807 7314851 7314738 ...
##  $ t_       : chr  "2021-01-28 08:01:13" "2021-01-28 12:00:50" "2021-01-28 16:00:41" "2021-01-28 20:
##  $ group    : chr  "Fed" "Fed" "Fed" "Fed" ...
```

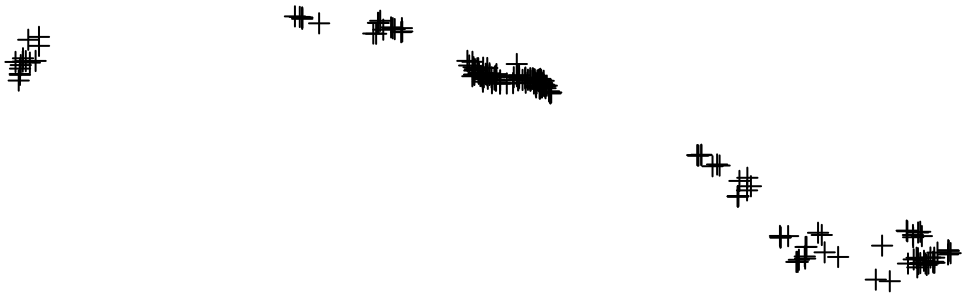
```
## Formal class 'SpatialPoints' [package "sp"] with 3 slots
##   ..@ coords     : num [1:2840, 1:2] 733989 733998 733986 734046 733624 ...
##   .. ..- attr(*, "dimnames")=List of 2
##   .. .. ..$ : NULL
##   .. .. ..$ : chr [1:2] "x_" "y_"
##   ..@ bbox       : num [1:2, 1:2] 716329 7313995 739215 7321141
##   .. ..- attr(*, "dimnames")=List of 2
##   .. .. ..$ : chr [1:2] "x_" "y_"
##   .. .. ..$ : chr [1:2] "min" "max"
##   ..@ proj4string:Formal class 'CRS' [package "sp"] with 1 slot
##   .. .. ..@ projargs: chr "+proj=utm +zone=33 +datum=WGS84 +units=m +no_defs"
##   .. .. ..$ comment: chr "PROJCRS[\"unknown\",\n    BASEGEOGCRS[\"unknown\",\n        DATUM[\"World
```

```
## class       : SpatialPoints
## features    : 1
## extent      : 733988.9, 733988.9, 7314723, 7314723  (xmin, xmax, ymin, ymax)
## crs         : +proj=utm +zone=33 +datum=WGS84 +units=m +no_defs
```

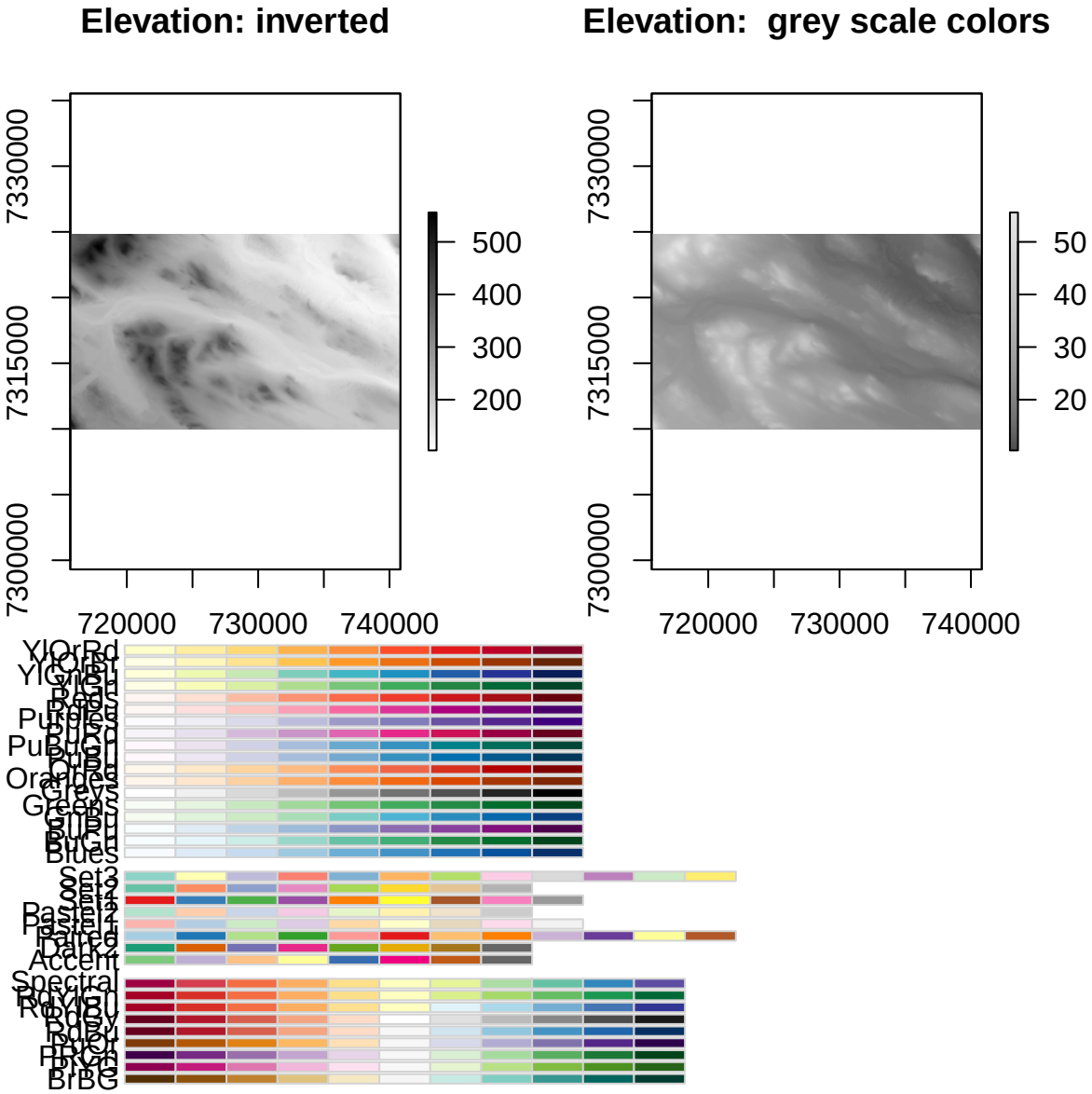
```
## [1] "SpatialPoints"
## attr(,"package")
## [1] "sp"
```



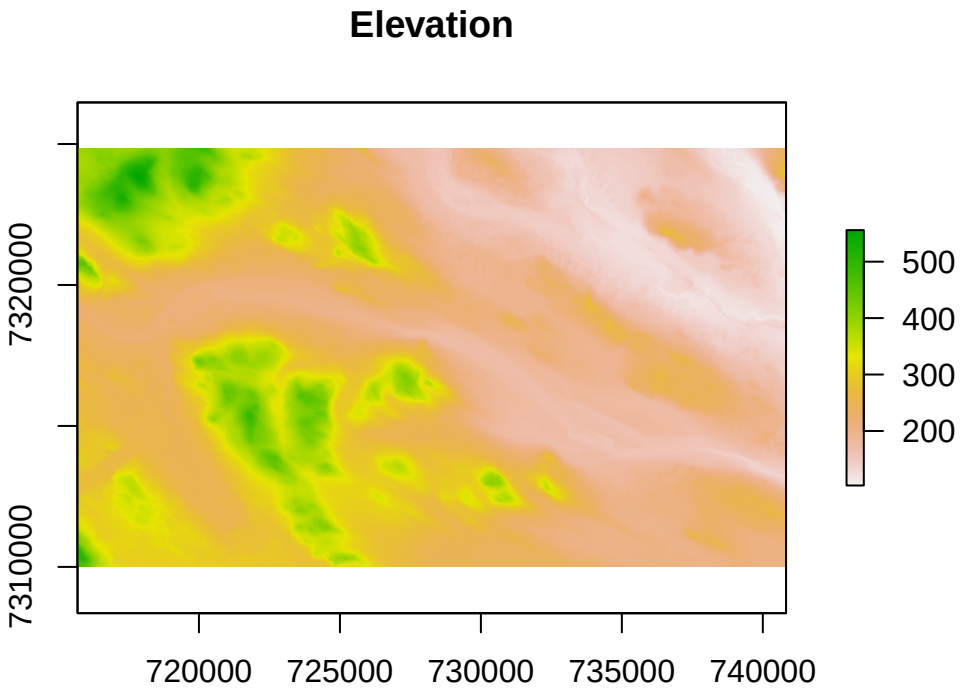
Animal position data (one ID)



Explore and select colors

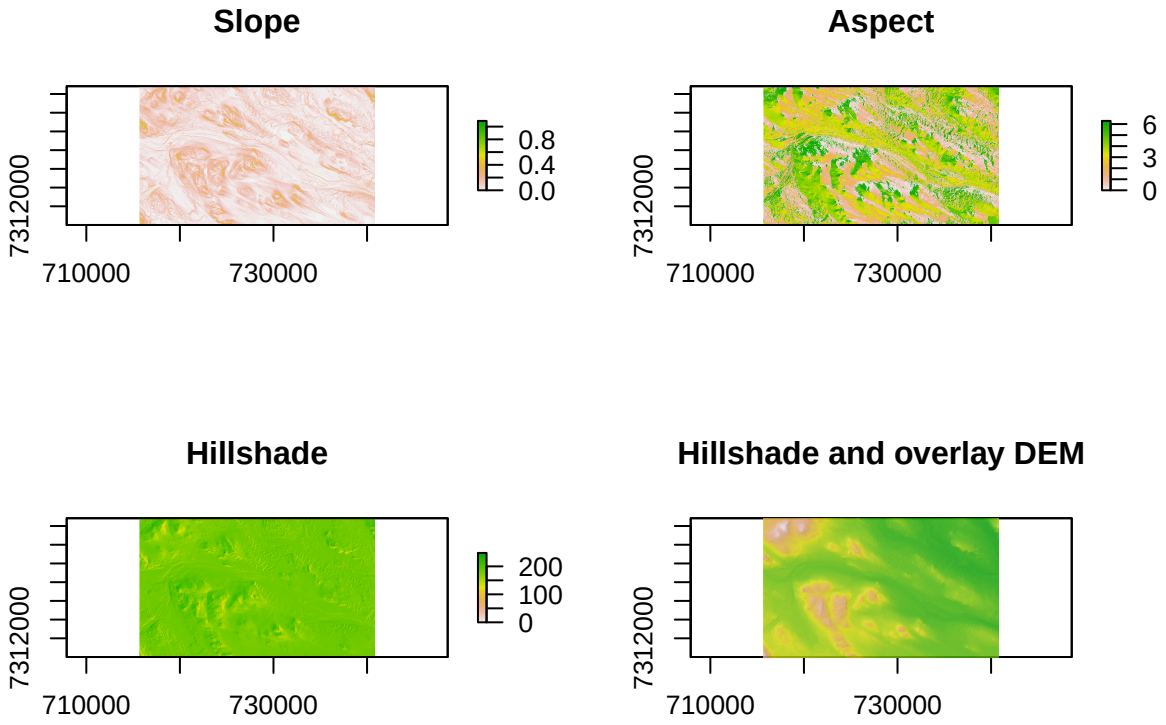



```
## [1] "#00A600" "#01A600" "#03A700" "#04A700" "#05A800" "#07A800"
```



Prepare hillshade background map to make a terrain type background

Calculate slope and aspect from elevation (dem)



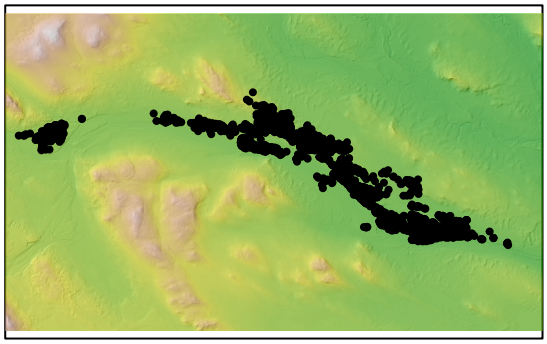
Plot and save all together (figure 2)

```
## Warning in plot.sf(HR_area, col = NA, border = 1, add = T): ignoring all but
```

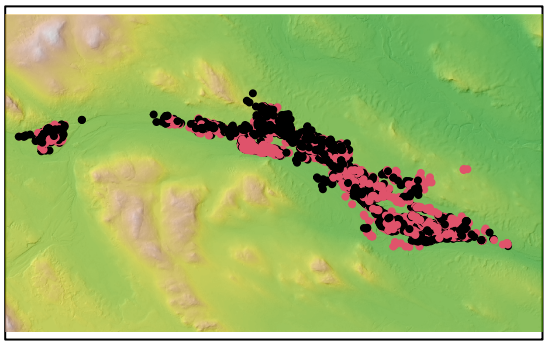
```
## the first attribute
```

A Plot fed inviduals

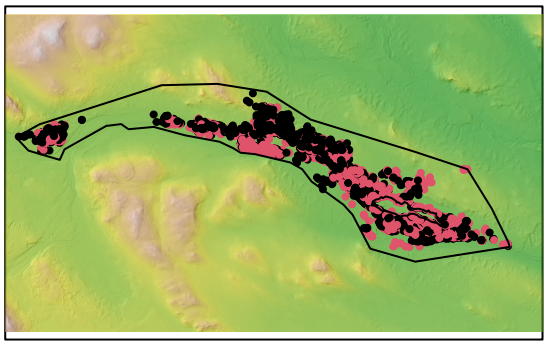
B Plot control individuals



C Plot all individuals



D Plot home range



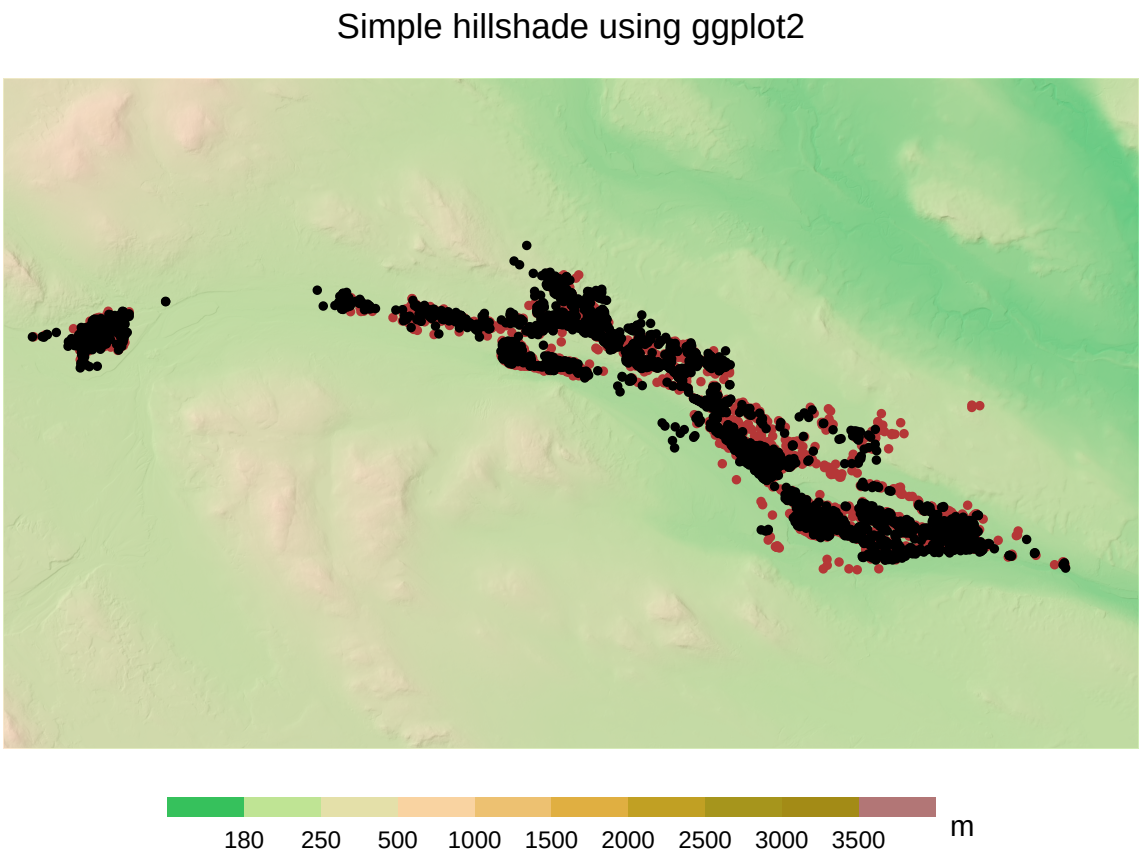
Saving it as ggplot (figure 3)

Some more packages required..

Credits to: https://dominicroye.github.io/blog/hillshade-effect/index.html

```
## class       : Extent
## xmin        : 715694
## xmax        : 740824
## ymin        : 7310002
## ymax        : 7324832
```

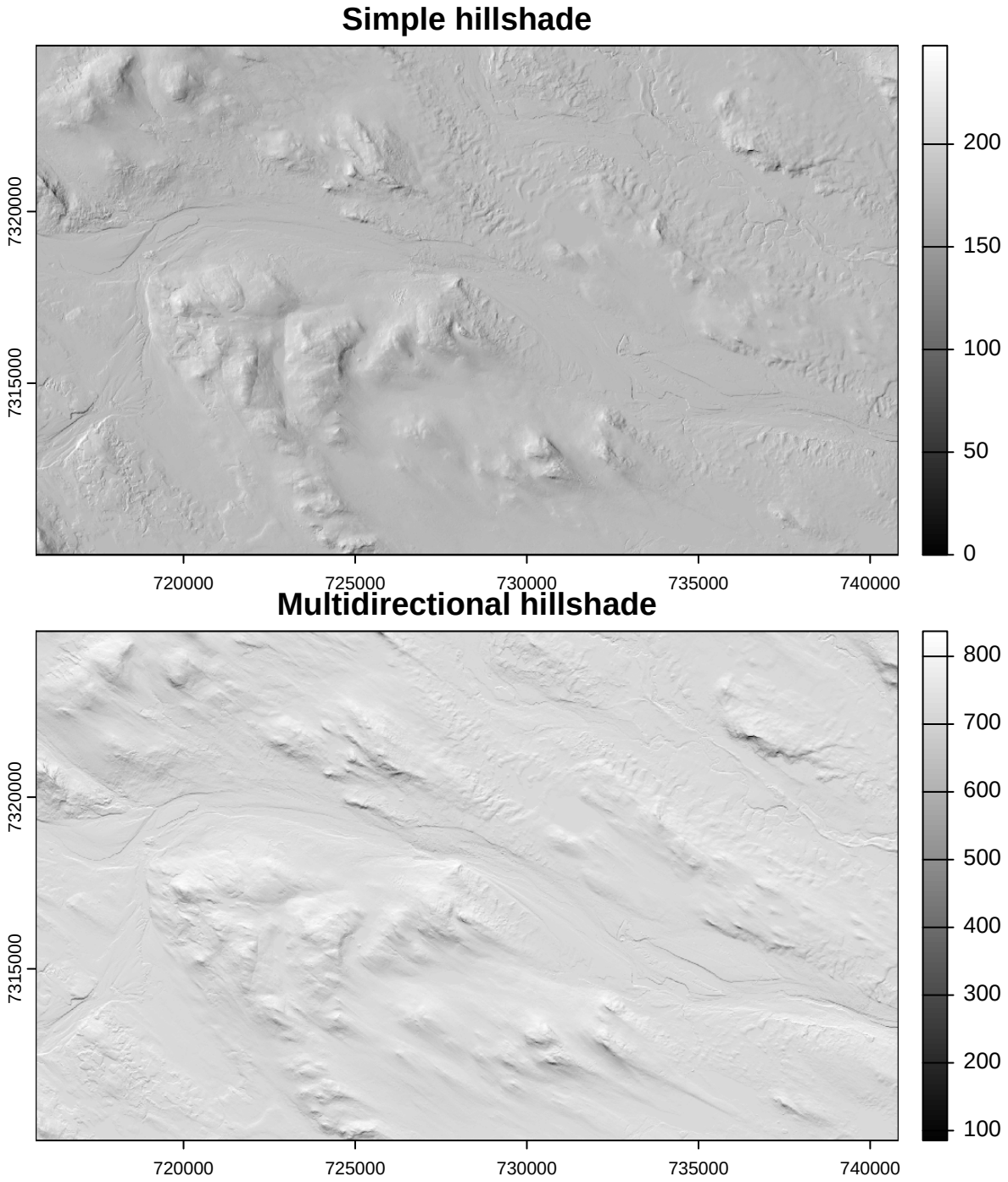
```
## [1] "SpatialPoints"
## attr(,"package")
## [1] "sp"
```



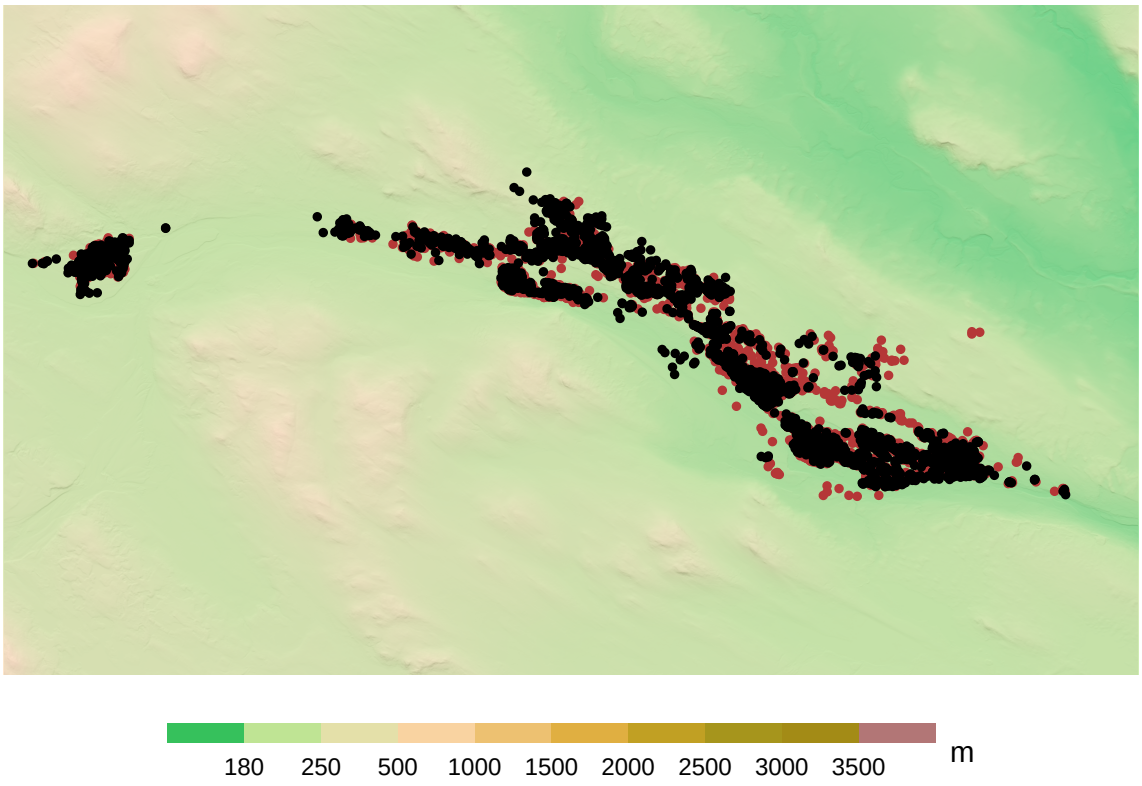
More examples

For figure 4-6 (in output_data/). Not included in the tutorial, but available as examples.

Multidimensional hillshade (figure 4)



Multidirectional hillshade using ggplot2



Multidimensional hillshade with blending

Example of creating multiplots ggplots and to save the maps (figure 6)

```
##
## Attaching package: 'ggpubr'

## The following object is masked from 'package:terra':
##
##     rotate

## The following object is masked from 'package:raster':
##
##     rotate
```

Figure 6