Lab 4: Spatial Data, Tmap, Bubble Plots

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Section 5.4 Exercise

https://bookdown.org/hhwagner1/LandGenCourse_book/r-exercise-week-2.html

a. Load libraries

```
require(adegenet)
require(LandGenCourse)
require(gstudio)
require(dplyr)
require(tibble)
require(sf)
```

b. Import data with gstudio

First downloading the data

```
if(!dir.exists(paste0(here(),"/downloads"))) dir.create(paste0(here(),"/downloads"))
file.copy(system.file("extdata", "ralu.loci.csv", package = "LandGenCourse"),
          paste0(here(), "/downloads/ralu.loci.csv"), overwrite=FALSE)
file.copy(system.file("extdata", "pulsatilla_genotypes.csv", package = "LandGenCourse"),
          paste0(here(), "/downloads/pulsatilla_genotypes.csv"), overwrite=FALSE)
```

Now loading the data with gstudio

```
g.Flr <- read_population("./downloads/pulsatilla_genotypes.csv",type = "column",locus.columns = c(6:19))

#g.Flr
```

c. Summarize by site

I would probably just use the function table(), but we can see where this takes us.

```
table(g.Flr$Population)
```

```
##
##  A03  A21  A25  A26  A41  A45 G05a
##   55   69  128   78   71   75   60
```

Recommend using groups_by from library dplyr, with nested functions n and summarize, and to Write the result into a new object Pulsatilla

summarize(nIndiv = n(g.Flr))

Example from Worked example: pland_sum_b <- percentage_forest_500_df %>% dplyr::group_by(plot_id) %>% dplyr::summarize(sum_pland = sum(value)) pland_sum_b

```
puls_df <- g.Flr %>%                  # create a df and piping
  dplyr::group_by(Population) %>%     # grouping by population and piping
  dplyr::summarize(nIndiv = n())      # summarize with n() and add name of column "nIndiv"
puls_df
```

```
## # A tibble: 7 x 2
##   Population nIndiv
##   <chr>       <int>
## 1 A03            55
## 2 A21            69
## 3 A25           128
## 4 A26            78
## 5 A41            71
## 6 A45            75
## 7 G05a           60
```

d. Add mean X and Y coordinates to object Pulsatilla

summarize(nIndiv = n(), myMean = n(myVar))

```
puls_df <- g.Flr %>%                  # create a df and piping
  dplyr::group_by(Population) %>%     # grouping by population and piping
  dplyr::summarize(nIndiv = n(), meanX = mean(X), meanY = mean(Y))     # summarize with n() and add nam
puls_df
```

```
## # A tibble: 7 x 4
##   Population nIndiv    meanX    meanY
##   <chr>       <int>    <dbl>    <dbl>
## 1 A03            55 4431316. 5429358.
## 2 A21            69 4426927. 5427171.
## 3 A25           128 4422659. 5425365.
## 4 A26            78 4422710. 5425139.
## 5 A41            71 4426037. 5423339.
## 6 A45            75 4423091. 5427002.
## 7 G05a           60 4429202. 5434947.
```

```
puls_df$meanX[2] == mean(g.Flr[g.Flr$Population == "A21",4])
```

```
## [1] TRUE
```

e. Convert to sf object

```
Sites <- as.data.frame(puls_df[,2:4])
rownames(Sites) <- puls_df$Population
colnames(Sites) <- c("n","X","Y")
Pulsatilla <- st_as_sf(Sites, coords=c("X", "Y"))
```

f. Specify the known projection

The correct EPSG number for this dataset is: 31468. You can specify the CRS with:

```
st_crs(Pulsatilla) <- 31468
```

```
Pulsatilla
```

```
## Simple feature collection with 7 features and 1 field
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 4422659 ymin: 5423339 xmax: 4431316 ymax: 5434947
## Projected CRS: DHDN / 3-degree Gauss-Kruger zone 4
##        n                geometry
## A03   55 POINT (4431316 5429358)
## A21   69 POINT (4426927 5427171)
## A25  128 POINT (4422659 5425365)
## A26   78 POINT (4422710 5425139)
## A41   71 POINT (4426037 5423339)
## A45   75 POINT (4423091 5427002)
## G05a  60 POINT (4429202 5434947)
```

g. Transform to lat/long projection

Adapt code from section 2.c to transform the projection to the "longlat" coordinate system, and write it into an object Pulsatilla.longlat.

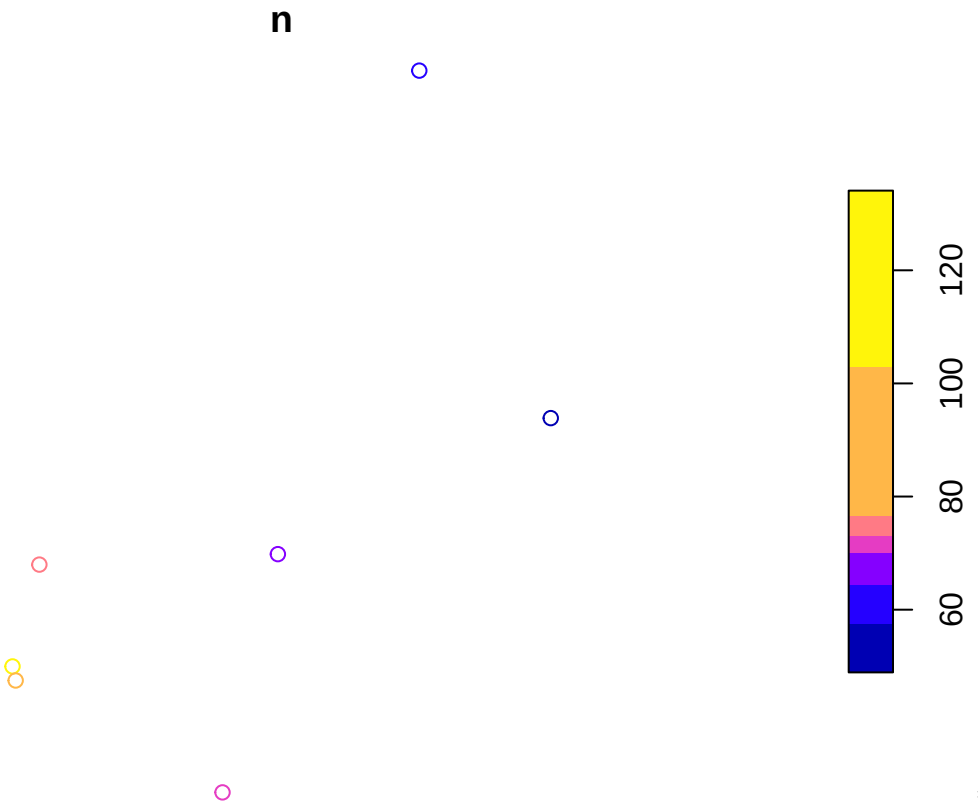
```
st_transform(Pulsatilla, crs = 4326)
```

```
## Simple feature collection with 7 features and 1 field
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 10.94239 ymin: 48.943 xmax: 11.05991 ymax: 49.04774
## Geodetic CRS:  WGS 84
##        n                   geometry
## A03   55 POINT (11.05991 48.99773)
## A21   69 POINT (11.00034 48.97756)
## A25  128  POINT (10.94239 48.9608)
## A26   78 POINT (10.94312 48.95877)
## A41   71   POINT (10.98887 48.943)
## A45   75 POINT (10.94798 48.97558)
## G05a  60 POINT (11.03004 49.04774)
```

```
Pulsatilla
```

```
## Simple feature collection with 7 features and 1 field
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 4422659 ymin: 5423339 xmax: 4431316 ymax: 5434947
## Projected CRS: DHDN / 3-degree Gauss-Kruger zone 4
##        n                geometry
## A03   55 POINT (4431316 5429358)
## A21   69 POINT (4426927 5427171)
## A25  128 POINT (4422659 5425365)
## A26   78 POINT (4422710 5425139)
## A41   71 POINT (4426037 5423339)
## A45   75 POINT (4423091 5427002)
## G05a  60 POINT (4429202 5434947)
```

```
plot(Pulsatilla)
```



h. Create bubble plot Adapt code from section 4.d to create a bubble plot of the number of individuals per population. Note: you may drop the argument key.entries as it has a default.

Here it is in live view mode, i don't need this in knitted output:

```
library(tmap)
tmap_mode("view")
tm_shape(Pulsatilla) + tm_bubbles(col="n")
```

Here it is again with plot mode so that I can have something in knitted output

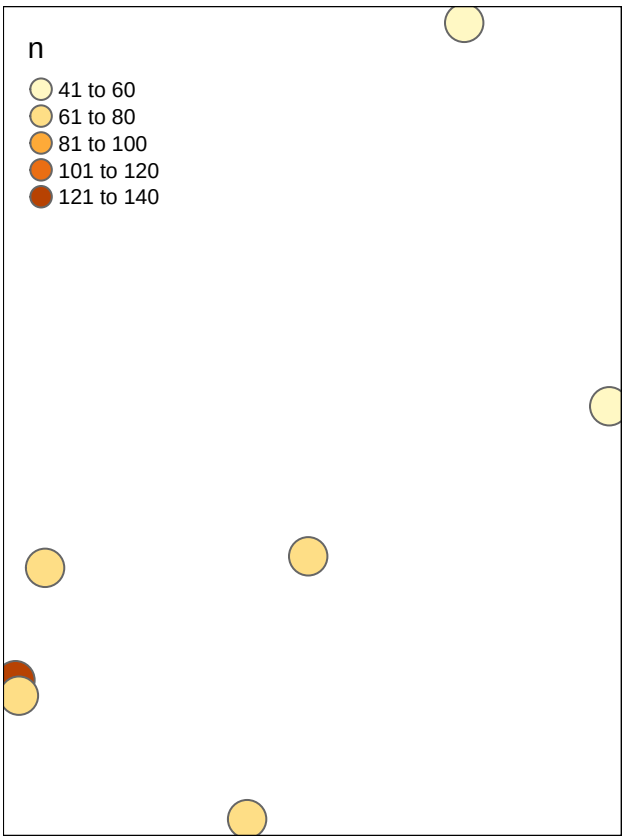
```
library(tmap)
```

```
## Breaking News: tmap 3.x is retiring. Please test v4, e.g. with
## remotes::install_github('r-tmap/tmap')
```

```
tmap_mode("plot")
```

```
## tmap mode set to plotting
```

```
tm_shape(Pulsatilla) + tm_bubbles(col="n")
```



i. Save data as R object

Save the object Pulsatilla.longlat as an R object using the following code:

```
saveRDS(Pulsatilla, file = "./output/Pulsatilla.longlat.rds")
```

We will need it for a later R exercise.

BONUS material, working with 'sf' and 'terra'

##1. Load libraries, need to install GeNetIt

```
library(LandGenCourse)
library(sf)
library(GeNetIt)
```

```
## Loading required package: nlme
```

```
##
## Attaching package: 'nlme'
```

```
## The following object is masked from 'package:dplyr':
##
##     collapse
```

```
library(terra)
```

```
## terra 1.7.83
```

```
library(tmap)
library(dplyr)
library(tibble)
library(here)
```

```
## here() starts at /uufs/chpc.utah.edu/common/home/u6036559/git/usu-biol4750
```

##2. import/export ESRI shape files a. Export 'sf' object to shapefile

```
data(ralu.site)
if(!dir.exists(here("output"))) dir.create(here("output"))
dir.create(here("output/Sites"))
```

```
## Warning in dir.create(here("output/Sites")):
## '/uufs/chpc.utah.edu/common/home/u6036559/git/usu-biol4750/output/Sites'
## already exists
```

```
st_write(ralu.site, here("output/Sites/Sites.shp"), delete_dsn = TRUE)
```

```
## Deleting source '/uufs/chpc.utah.edu/common/home/u6036559/git/usu-biol4750/output/Sites/Sites.shp' us
## Writing layer 'Sites' to data source
##   '/uufs/chpc.utah.edu/common/home/u6036559/git/usu-biol4750/output/Sites/Sites.shp' using driver 'ES
## Writing 31 features with 17 fields and geometry type Point.
```

b. Import shapefile to 'sf' object

```
Sites.sf_a <- st_read(here("output/Sites/Sites.shp"))
```

```
## Reading layer 'Sites' from data source
##   '/uufs/chpc.utah.edu/common/home/u6036559/git/usu-biol4750/output/Sites/Sites.shp'
##   using driver 'ESRI Shapefile'
## Simple feature collection with 31 features and 17 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 686908.5 ymin: 4994089 xmax: 690890.1 ymax: 5004435
## Projected CRS: NAD83 / UTM zone 11N
```

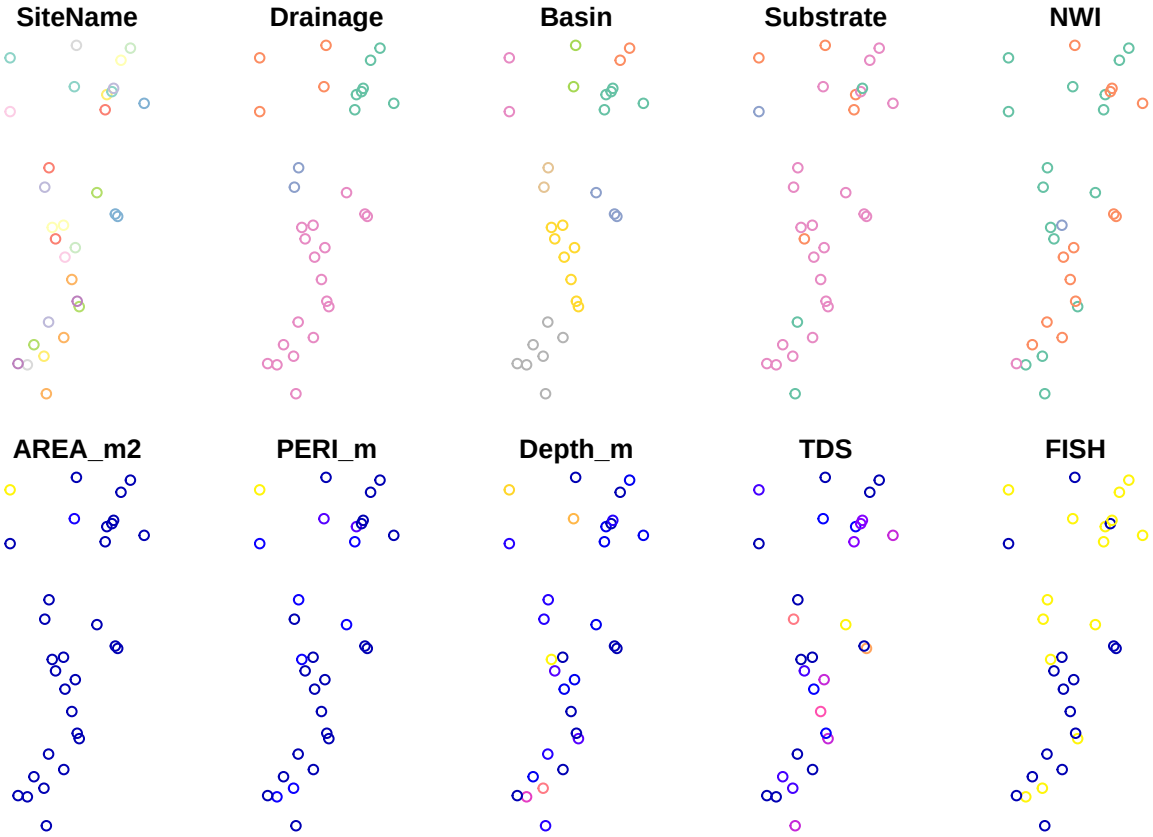
```
Sites.sf_a
```

```
## Simple feature collection with 31 features and 17 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 686908.5 ymin: 4994089 xmax: 690890.1 ymax: 5004435
## Projected CRS: NAD83 / UTM zone 11N
## First 10 features:
##          SiteName        Drainage      Basin Substrate
## 1    AirplaneLake ShipIslandCreek Sheepeater      Silt
## 2  BachelorMeadow     WilsonCreek    Skyhigh      Silt
## 3  BarkingFoxLake  WaterfallCreek    Terrace      Silt
## 4    BirdbillLake      ClearCreek   Birdbill      Sand
## 5         BobLake     WilsonCreek     Harbor      Silt
## 6       CacheLake     WilsonCreek    Skyhigh      Silt
## 7         DoeLake     WilsonCreek    Skyhigh      Silt
## 8    EggWhiteLake     WilsonCreek    Skyhigh      Silt
## 9      ElenasLake ShipIslandCreek Sheepeater      Sand
## 10       FawnLake     WilsonCreek    Skyhigh      Silt
##                              NWI AREA_m2 PERI_m Depth_m  TDS FISH ACB   AUC
## 1                     Lacustrine 62582.2 1142.8   21.64  2.5    1   0 0.411
```

```
## 2  Riverine_Intermittent_Streambed   225.0   60.0    0.40  0.0    0   0 0.000
## 3                       Lacustrine 12000.0  435.0    5.00 13.8    1   0 0.300
## 4                       Lacustrine 12358.6  572.3    3.93  6.4    1   0 0.283
## 5                       Palustrine  4600.0  321.4    2.00 14.3    0   0 0.000
## 6                       Palustrine  2268.8  192.0    1.86 10.9    0   0 0.000
## 7                       Lacustrine 13034.9  463.2    6.03 10.0    1   0 0.415
## 8                       Palustrine  4544.5  291.9    3.30  2.4    0   0 0.000
## 9                       Palustrine     0.0    0.0    0.00  0.0    0   0 0.000
## 10                      Palustrine  3865.9  237.7    1.98  3.6    0   0 0.000
##     AUCV  AUCC   AUF AWOOD  AUFV                  geometry
## 1  0.000 0.411 0.063 0.063 0.464 POINT (688816.6 5003207)
## 2  0.000 0.000 1.000 0.000 0.000 POINT (688494.4 4999093)
## 3  0.000 0.300 0.700 0.000 0.000 POINT (687938.4 5000223)
## 4  0.000 0.283 0.717 0.000 0.000 POINT (689732.8 5002522)
## 5  0.000 0.000 0.500 0.000 0.500   POINT (690104 4999355)
## 6  0.000 0.000 0.556 0.093 0.352 POINT (688742.5 4997481)
## 7  0.171 0.585 0.341 0.000 0.073 POINT (688962.4 4996675)
## 8  0.047 0.047 0.686 0.209 0.058 POINT (688539.3 4998146)
## 9  0.000 0.000 0.000 0.000 0.000 POINT (688878.7 5004435)
## 10 0.000 0.000 1.000 0.000 0.000 POINT (688901.5 4996837)
```

```
plot(Sites.sf_a)
```

```
## Warning: plotting the first 10 out of 17 attributes; use max.plot = 17 to plot
## all
```



As sp

```
data(ralu.site)
Sites.sp <- sf::as_Spatial(ralu.site)
```

```
Sites.sp
```

```
## class       : SpatialPointsDataFrame
## features    : 31
## extent      : 686908.5, 690890.1, 4994089, 5004435  (xmin, xmax, ymin, ymax)
## crs         : +proj=utm +zone=11 +datum=NAD83 +units=m +no_defs
## variables   : 17
## names       :     SiteName,    Drainage,    Basin, Substrate,
## min values  : AirplaneLake,  ClearCreek, Birdbill,    Cobble,                                        Lacus
## max values  :  WelcomeLake, WilsonCreek,   TipTop,      Silt, Riverine_UpperPerennial_Unconsolidated
```

Convert back to sf

```
Sites.sf_b <- sf::st_as_sf(Sites.sp)
Sites.sf_b
```

```
## Simple feature collection with 31 features and 17 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 686908.5 ymin: 4994089 xmax: 690890.1 ymax: 5004435
## Projected CRS: +proj=utm +zone=11 +datum=NAD83 +units=m +no_defs
## First 10 features:
##          SiteName        Drainage      Basin Substrate
## 1    AirplaneLake ShipIslandCreek Sheepeater      Silt
## 2  BachelorMeadow     WilsonCreek    Skyhigh      Silt
## 3  BarkingFoxLake  WaterfallCreek    Terrace      Silt
## 4    BirdbillLake      ClearCreek   Birdbill      Sand
## 5         BobLake     WilsonCreek     Harbor      Silt
## 6       CacheLake     WilsonCreek    Skyhigh      Silt
## 7         DoeLake     WilsonCreek    Skyhigh      Silt
## 8    EggWhiteLake     WilsonCreek    Skyhigh      Silt
## 9      ElenasLake ShipIslandCreek Sheepeater      Sand
## 10       FawnLake     WilsonCreek    Skyhigh      Silt
##                                NWI AREA_m2 PERI_m Depth_m  TDS FISH ACB   AUC
## 1                        Lacustrine 62582.2 1142.8   21.64  2.5    1   0 0.411
## 2  Riverine_Intermittent_Streambed   225.0   60.0    0.40  0.0    0   0 0.000
## 3                        Lacustrine 12000.0  435.0    5.00 13.8    1   0 0.300
## 4                        Lacustrine 12358.6  572.3    3.93  6.4    1   0 0.283
## 5                        Palustrine  4600.0  321.4    2.00 14.3    0   0 0.000
## 6                        Palustrine  2268.8  192.0    1.86 10.9    0   0 0.000
## 7                        Lacustrine 13034.9  463.2    6.03 10.0    1   0 0.415
## 8                        Palustrine  4544.5  291.9    3.30  2.4    0   0 0.000
## 9                        Palustrine     0.0    0.0    0.00  0.0    0   0 0.000
## 10                       Palustrine  3865.9  237.7    1.98  3.6    0   0 0.000
##     AUCV  AUCC   AUF AWOOD  AUFV                 geometry
## 1  0.000 0.411 0.063 0.063 0.464 POINT (688816.6 5003207)
## 2  0.000 0.000 1.000 0.000 0.000 POINT (688494.4 4999093)
## 3  0.000 0.300 0.700 0.000 0.000 POINT (687938.4 5000223)
## 4  0.000 0.283 0.717 0.000 0.000 POINT (689732.8 5002522)
## 5  0.000 0.000 0.500 0.000 0.500   POINT (690104 4999355)
## 6  0.000 0.000 0.556 0.093 0.352 POINT (688742.5 4997481)
## 7  0.171 0.585 0.341 0.000 0.073 POINT (688962.4 4996675)
## 8  0.047 0.047 0.686 0.209 0.058 POINT (688539.3 4998146)
## 9  0.000 0.000 0.000 0.000 0.000 POINT (688878.7 5004435)
## 10 0.000 0.000 1.000 0.000 0.000 POINT (688901.5 4996837)
```

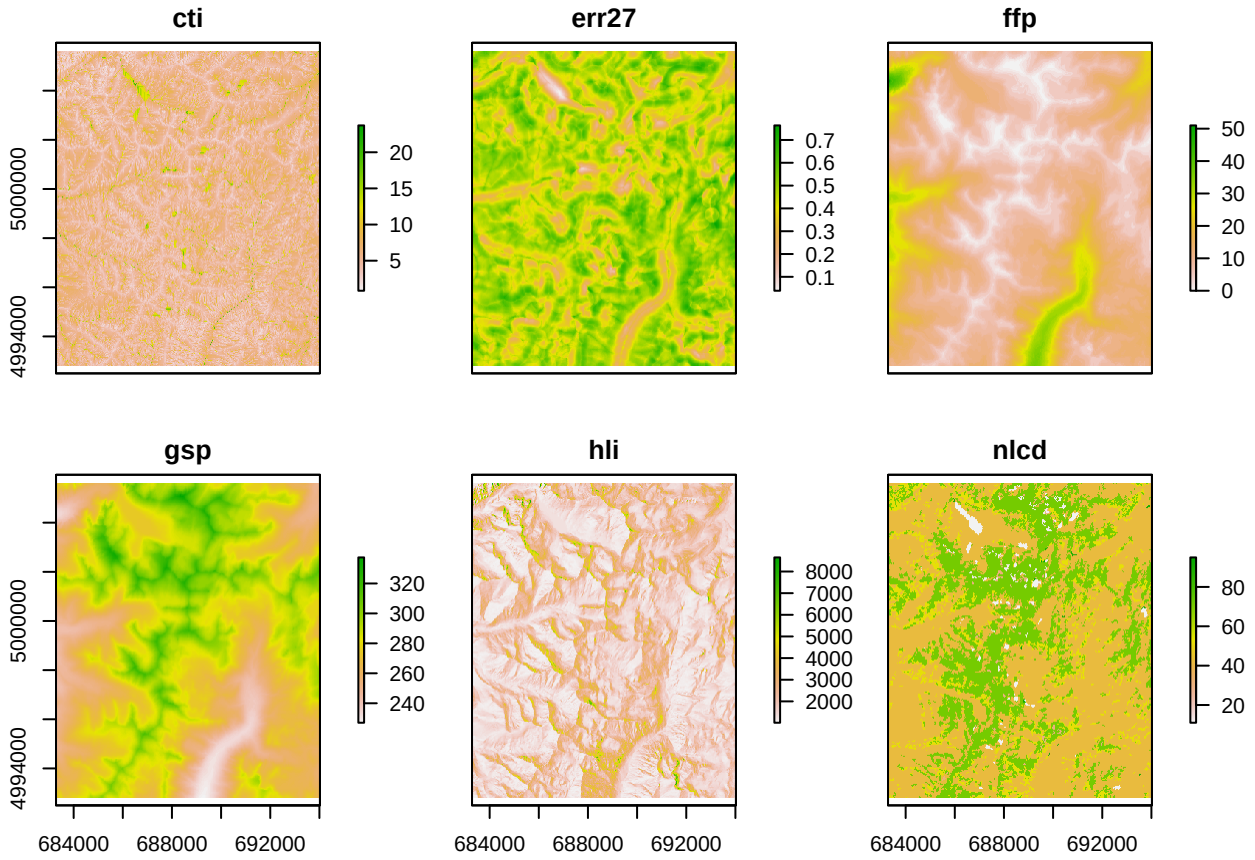
b. Converting between terra and raster

```
RasterMaps <- rast(system.file("extdata/covariates.tif", package="GeNetIt"))

RasterMaps.r <- raster::stack(RasterMaps)
RasterMaps.r
```

```
## class      : RasterStack
## dimensions : 426, 358, 152508, 6  (nrow, ncol, ncell, nlayers)
## resolution : 30, 30  (x, y)
## extent     : 683282.5, 694022.5, 4992833, 5005613  (xmin, xmax, ymin, ymax)
## crs        : +proj=utm +zone=11 +datum=NAD83 +units=m +no_defs
## names      :          cti,        err27,          ffp,          gsp,          hli,         nlcd
## min values : 8.429851e-01, 3.906551e-02, 0.000000e+00, 2.270000e+02, 1.014000e+03, 1.100000e+01
## max values :   23.7147598,    0.7637643,   51.0000000,  338.0696716, 9263.0000000,   95.0000000
```

```
plot(RasterMaps.r)
```



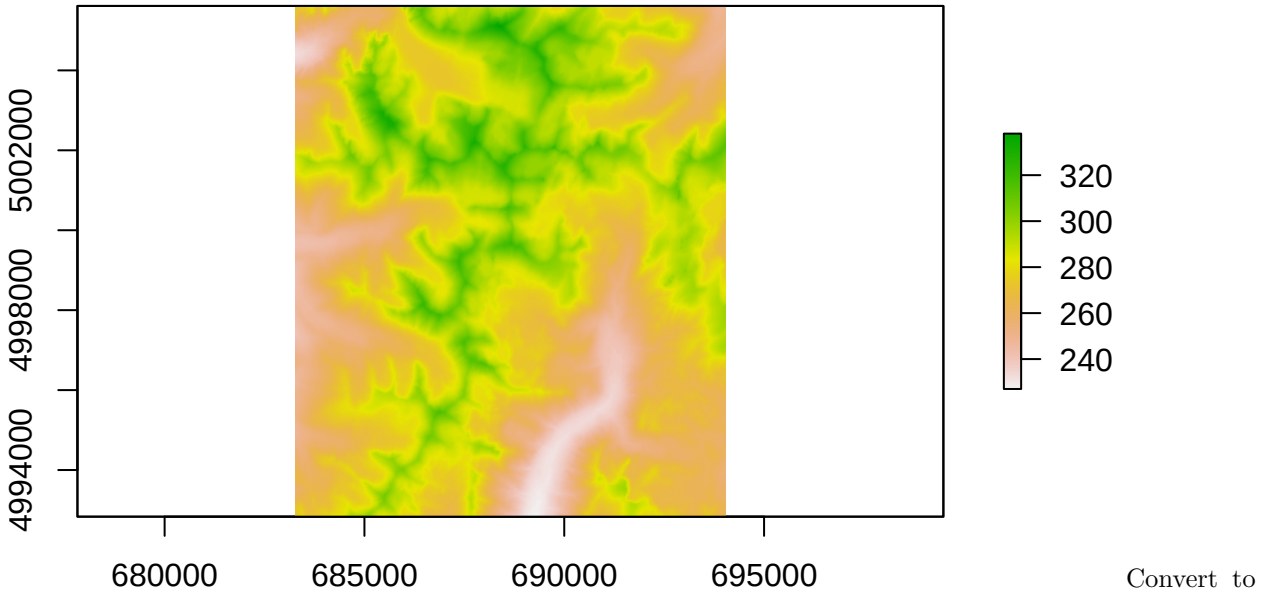
grab one layer

```
gsp.r <- raster::raster(RasterMaps$gsp)
gsp.r
```

```
## class      : RasterLayer
## band       : 4  (of  6  bands)
## dimensions : 426, 358, 152508  (nrow, ncol, ncell)
## resolution : 30, 30  (x, y)
## extent     : 683282.5, 694022.5, 4992833, 5005613  (xmin, xmax, ymin, ymax)
## crs        : +proj=utm +zone=11 +datum=NAD83 +units=m +no_defs
```

```
## source     : covariates.tif
## names      : gsp
## values     : 227, 338.0697  (min, max)
```

```
plot(gsp.r)
```

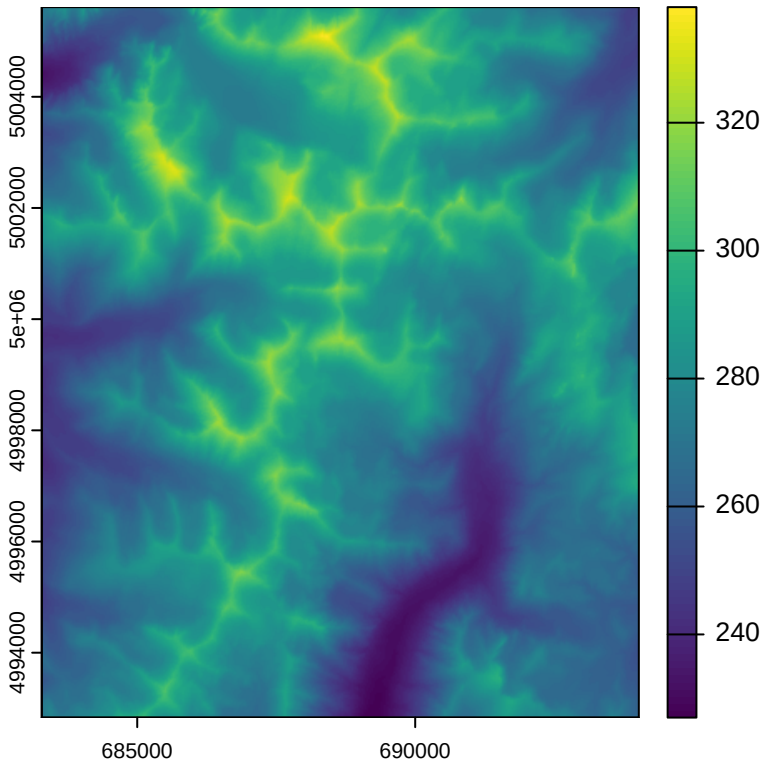


Convert to "terra"

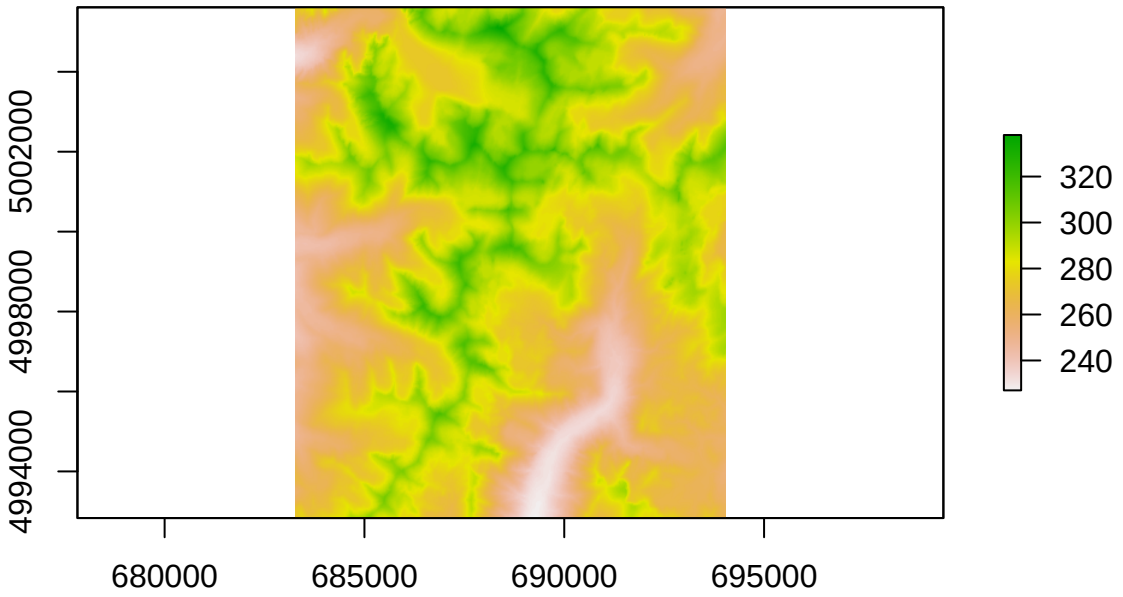
```
gsp <- terra::rast(gsp.r)
gsp
```

```
## class       : SpatRaster
## dimensions  : 426, 358, 1  (nrow, ncol, nlyr)
## resolution  : 30, 30  (x, y)
## extent      : 683282.5, 694022.5, 4992833, 5005613  (xmin, xmax, ymin, ymax)
## coord. ref. : +proj=utm +zone=11 +datum=NAD83 +units=m +no_defs
## source      : covariates.tif
## name        :      gsp
## min value   : 227.0000
## max value   : 338.0697
```

```
plot(gsp)
```




```
plot(gsp.r)
```




```
RasterMaps_b <- terra::rast(RasterMaps.r)
RasterMaps_b
```

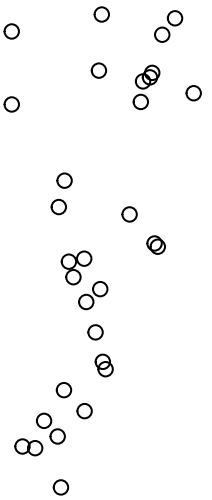
```
## class       : SpatRaster
## dimensions  : 426, 358, 6  (nrow, ncol, nlyr)
## resolution  : 30, 30  (x, y)
## extent      : 683282.5, 694022.5, 4992833, 5005613  (xmin, xmax, ymin, ymax)
## coord. ref. : +proj=utm +zone=11 +datum=NAD83 +units=m +no_defs
## source      : covariates.tif
```

```
## names       :        cti,      err27, ffp,      gsp,  hli, nlcd
## min values  :  0.8429851, 0.03906551,   0, 227.0000, 1014,   11
## max values  : 23.7147598, 0.76376426,  51, 338.0697, 9263,   95
```

4. Plotting spatial data with tmap

a. Plotting just the geometry from the data stored in sf object

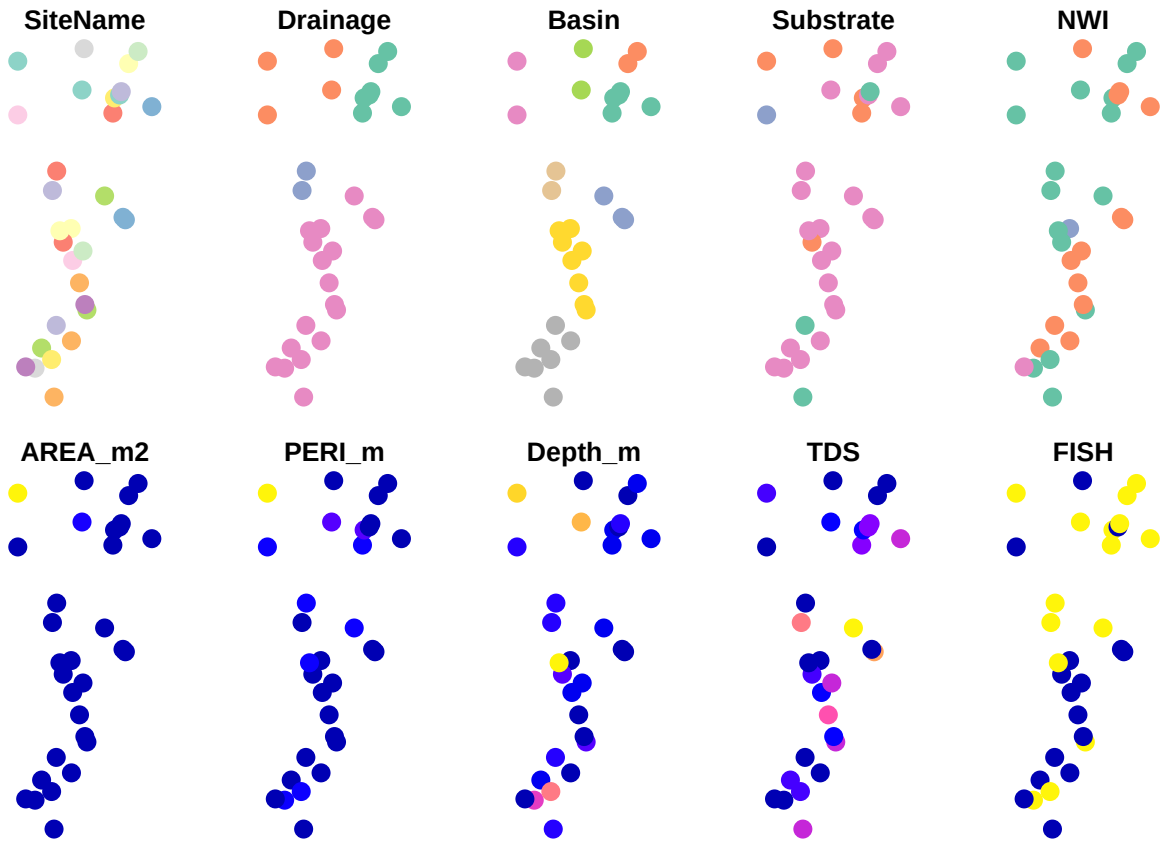
```
data(ralu.site)
Sites.sf_c <- ralu.site
plot(st_geometry(Sites.sf_c))
```



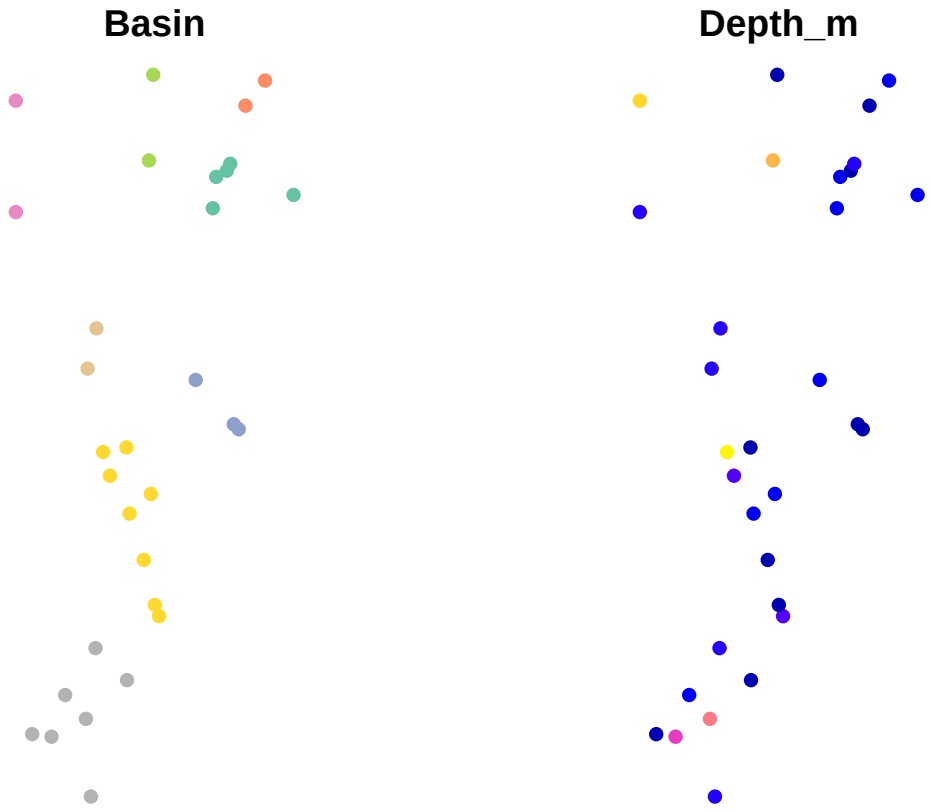
b. Plot the attributes

```
par(mar=c(2,2,2,2))
plot(Sites.sf_c, pch=16, cex=2)
```

```
## Warning: plotting the first 10 out of 17 attributes; use max.plot = 17 to plot
## all
```




```
plot(Sites.sf_c[,c("Basin", "Depth_m")], pch=16)
```



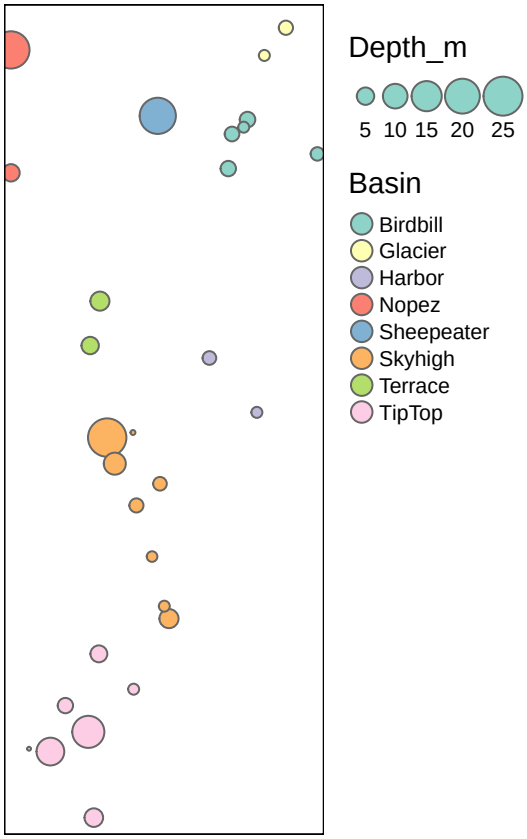
```
plot(Sites.sf_c[,c(3,8)], pch=16)
```

c. bubble plot with tmap library

```
tmap_mode("plot")
```

```
## tmap mode set to plotting
```

```
tm_shape(Sites.sf_c) + tm_bubbles(size="Depth_m", col="Basin") +
  tm_layout(legend.outside=TRUE, legend.outside.position="right")
```



Extend extent of the plot

```
Bbox = st_bbox(Sites.sf_c)
Bbox
```

```
##      xmin      ymin      xmax      ymax
##  686908.5 4994089.3  690890.1 5004435.0
```

```
#expand this by a factor of 0.1
delta.x <- Bbox[3] - Bbox[1]
delta.y <- Bbox[4] - Bbox[2]
Zoom <- 0.2
Bbox2 <- Bbox + c(-delta.x, -delta.y, delta.x, delta.y) * Zoom
Bbox2
```

```
##      xmin      ymin      xmax      ymax
##  686112.2 4992020.2  691686.4 5006504.1
```

```
tmap_mode("plot")
```

```
## tmap mode set to plotting
```

```
Map1 <- tm_shape(Sites.sf_c, bbox=Bbox2) +
  tm_bubbles(size="Depth_m", col="Basin") +
  tm_layout(legend.outside=TRUE, legend.outside.position="right")
Map1
```