bfsMaps - Swiss Maps 'ThemaKart'

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The representation of map material with R is powerful and flexible, but also quite technically organized, and therefore challenging for occasional users. In order to reduce the complexity of the task, this R package has been created to allow Swiss cantons, districts and municipal information to be displayed more quickly and easily. High quality maps for Switzerland are available free of charge from the Swiss Federal Office of Statistics (SFOS/BfS).

'bfsMaps' uses functions from the packages 'maptools', 'sp', 'rgdal', 'spdep', 'rlang', 'DescTools' available on CRAN, which must be installed additionally:

```
install.packages(c("maptools", "sp", "rgeos", "spdep", "rlang"))
```

Questions, comments and bug reports are welcome! Thank you.

Note: For all the examples in this document, `library(bfsMaps)` must be declared.

1 Installation

'ThemaKart', the SFSO cartographic centre, offers numerous map bases (geometries) for most official geographic divisions, which are used in maps and atlases of the Federal Statistical Office. An annually updated set of these geometries is freely available.

Federal Statistical Office Service 'ThemaKart'
Espace de l'Europe 10
CH-2010 Neuchâtel
Switzerland

engl:
https://www.bfs.admin.ch/bfs/en/home/statistics/regional-statistics/base-maps/cartographic-bases.html

german:
https://www.bfs.admin.ch/bfs/de/home/statistiken/regionalstatistik/kartengrundlagen/basisgeometrien.html

The Cartographic bases set contains the latest years and the state for the Population Censuses of 2000 and 2010 for the major geographic divisions, plus additional years for communes and districts, polygons for districts within the 17 largest Swiss cities. Total areas are shown in polygons which come in two versions: total area surfaces (`gf`, ge: "Gesamtfläche") and vegetation surfaces (`vf`, ge: "Vegetationsfläche"). Additionally, the topographic information is enriched by numerous layers for lakes and rivers.
There is also a detailed information brochure with more information on the contents and references behind this offer, as well as a list of nomenclatures used and the application of copyrights (brochure available only in German and French).

For the use with this package the maps must be downloaded separately and unpacked into any folder. The root folder must then be declared as an option in the R options, e.g.:

```
options(bfsMaps.base="C:/Users/andri/Documents/MapData/ThemaKart2020")
```

The 'bfsMaps' package uses a meta file containing the path information for accessing the maps. This file is named `maps.csv` and can either be located in the root directory of the mapdata or in the `/extdata` directory of the package (usually `~/extdata`, where `~` is the library path returned by `system.file(package="bfsMaps")`). The `RequireMap()` function will search for it along these two paths, taking the first file it finds.
The file consists of an optional shortname for the maps and the according path to the shapefile (with the extension `.shp`).

	A	B
1	name_x	path_x
2	fluss1.map	00_TOPO/K4_flusyyyymmdd/k4flusyyyymmdd11_ch2007.shp
3	fluss2.map	00_TOPO/K4_flusyyyymmdd/k4flusyyyymmdd22_ch2007.shp
4	fluss3.map	00_TOPO/K4_flusyyyymmdd/k4flusyyyymmdd33_ch2007.shp
5	fluss4.map	00_TOPO/K4_flusyyyymmdd/k4flusyyyymmdd44_ch2007.shp
6	fluss5.map	00_TOPO/K4_flusyyyymmdd/k4flusyyyymmdd55_ch2007.shp
7	see1.map	00_TOPO/K4_seenyyyymmdd/k4seenyyyymmdd11_ch2007Poly.shp
8	see2.map	00_TOPO/K4_seenyyyymmdd/k4seenyyyymmdd22_ch2007Poly.shp
9	stkt.pnt	00_TOPO/K4_stkt19970101/k4stkt19970101kk_ch2007Pnts.shp
10		01_INST/Gesamtfläche_gf/K4_bezk20001205_gf/K4bezk20001205gf_ch2007Poly.shp
11		01_INST/Gesamtfläche_gf/K4_bezk20001205_gf/K4bezk20001205zg_ch2007Pnts.shp
12		01_INST/Gesamtfläche_gf/K4_bezk20101231_gf/K4bezk20101231gf_ch2007Poly.shp

For the specific functions `PlotKant()`, `PlotPolg()`, etc. to work, the according short names must be found in the `maps.csv` file.

These are:

type	stem	map	pnt	vf.map	vf.pnt	used by
Rivers 1 (large)	fluss1	x				`AddRivers()`
Rivers 2	fluss2	x				`AddRivers()`
Rivers 3	fluss3	x				`AddRivers()`
Rivers 4	fluss4	x				`AddRivers()`
Rivers 5 (small)	fluss5	x				`AddRivers()`
Lakes (large)	see1	x				`AddLakes()`
Lakes (small)	see2	x				`AddLakes()`
Capitals of cantons	stkt		x	x	x	
Switzerland	ch	x	x	x	x	`PlotCH()`
Greater Regions	greg	x	x	x	x	`PlotGreg()`
Cantons	kant	x	x	x	x	`PlotKant()`
MS Regions	msre	x	x	x	x	`PlotMSRe()`
Districts	bezk	x	x	x	x	`PlotBezk()`
Municipalities	polg	x	x	x	x	`PlotPolg()`
Metropolitan areas	metr	x	x	x	x	`PlotMetr()`

`vf.map` denotes the maps with vegetational area, `pnt` are the centroid points of the specific area, `map` is the general map.

A default `maps.csv` file is included in the package, based on the filenames of 'ThemaKart' 2020 ©. So earlier data can be displayed as well with the same functions, but then the user must make sure, that the `maps.csv` is updated correctly and points to the appropriate maps.

The required installation steps for using the 'bfsMaps' package are:

1. Download maps zip file from www.bfs.admin.ch: Basisgeometrien (de), cartographic-bases (engl)

2. Unzip and place maps somewhere in your filesystem.
   E.g.: C:\Users\Andri\Documents\MapData\ThemaKart2020

3. Set R `options(bfsMaps.base="your directory where you placed the maps").`
   E.g.: options(bfsMaps.base = "C:/Users/andri/Documents/MapData/ThemaKart2020")

4. Make sure maps.csv in `system.file(package="bfsMaps")/extdata` is correct
5. Use package…

As long as the url is valid, the function

```
DownloadBfSMaps(url="https://www.bfs.admin.ch/bfsstatic/dam/assets/11927607/master",
                path=paste0(path.expand("~"), "/MapData"))
```

will do the job above and return the required string for the options file.

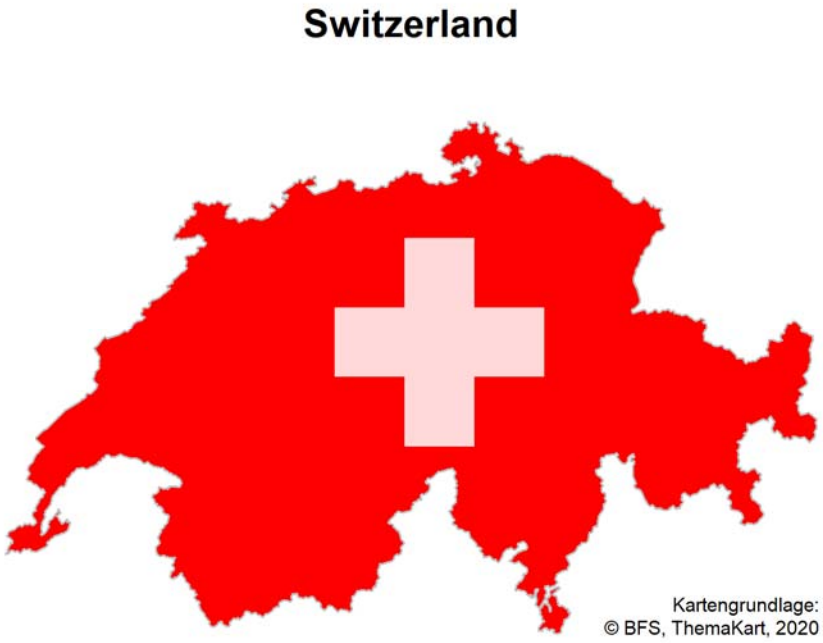
Switching between maps of different years can so be performed by setting the `bfsMaps.base` option to the required map library.

Have fun and success!

2 Plot Switzerland

The first example represents the whole of Switzerland without any small-scale division. The waters can either be included by setting the argument `panel.first(AddLakes())` or be omitted in the `PlotCH()` function for the time being so that they can be added later by the functions `AddLakes()` and `AddRivers()`, if e.g. other colors are required.

```
library(bfsMaps)
# set the path to the map root directory
options(bfsMaps.base="C:/Users/andri/Documents/MapData/ThemaKart2020")


# Plot Switzerland map in borders of 1848
PlotCH(col="red")

sw <- 15000; xc <- 2671975; yc <- 1200600; ccol <- rgb(1,1,1,0.85)
rect(xleft=xc-sw, ytop=yc-sw, xright=xc+sw, ybottom=yc+sw, col=ccol, border=NA)
rect(xleft=(xc-2*sw)-sw, ytop=yc-sw, xright=(xc-2*sw)+sw, ybottom=yc+sw,
     col=ccol, border=NA)
rect(xleft=(xc+2*sw)-sw, ytop=yc-sw, xright=(xc+2*sw)+sw, ybottom=yc+sw,
     col=ccol, border=NA)
rect(xleft=xc-sw, ytop=(yc-2*sw)-sw, xright=xc+sw, ybottom=(yc-2*sw)+sw,
     col=ccol, border=NA)
rect(xleft=xc-sw, ytop=(yc+2*sw)-sw, xright=xc+sw, ybottom=(yc+2*sw)+sw,
     col=ccol, border=NA)

title(main="Switzerland")
```



3 Plot Swiss Cantons

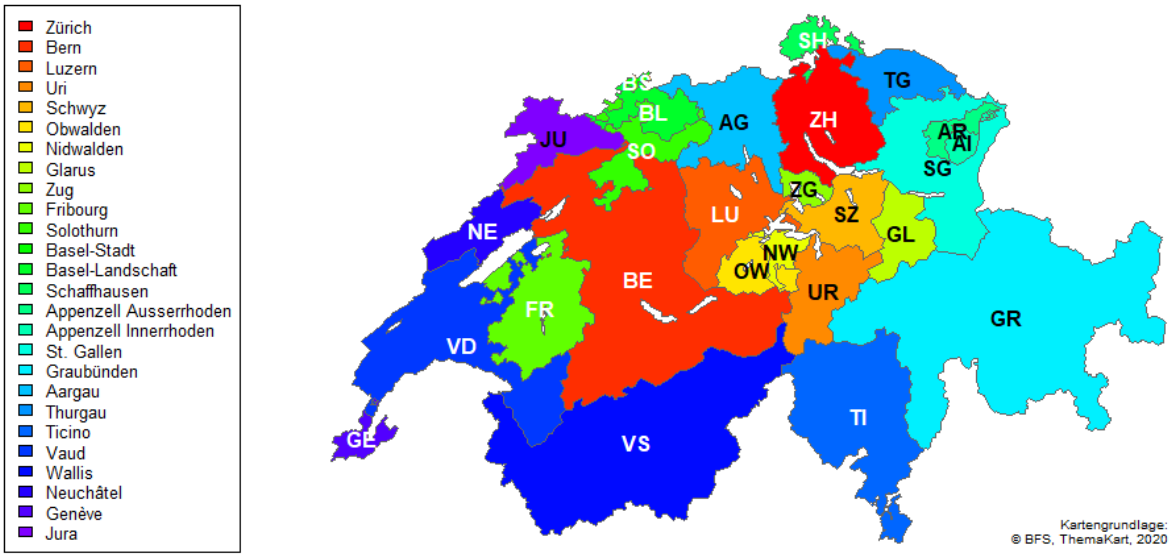
Plot of the cantons with the canton names in the (area) centroid of the canton. The area centroids of the cantons are available in the dataset `kant.pnt` as x, y coordinates. This allows texts to be written directly on the map.

- Do everything by hand:

```
# Plot cantons in colorful way
RequireMap(c("kant.map", "kant.pnt"))
par(mar=c(5.1, 10.1, 5.1, 2.1), xpd=TRUE)
cols <- rainbow(start = 0, end = 0.75, n=26)
plot(tkart$kant.map, usePolypath=TRUE, col=cols)
legend(x="left", inset=-0.25, legend=tkart$kant.map@data$ID1,
       fill=cols, bg="white", cex=0.8, xpd=NA)

# Put text on the centroids of the cantons
text(tkart$kant.pnt, labels=unique(d.bfsrg$kt_x), col=TextContrastColor(cols),
font=1)
```

- Use specialized function `PlotKant()`:

```
Mar(left=15)
b <- PlotKant(col=cols, border="grey40")
text(b, labels = kt, col=TextContrastColor(cols), font=2)
legend(x="left", inset=-0.325, legend=tkart$kant.map@data$ID1,
       fill=cols, bg="white", cex=0.8, xpd=NA)
```



4 Cantons with capitals

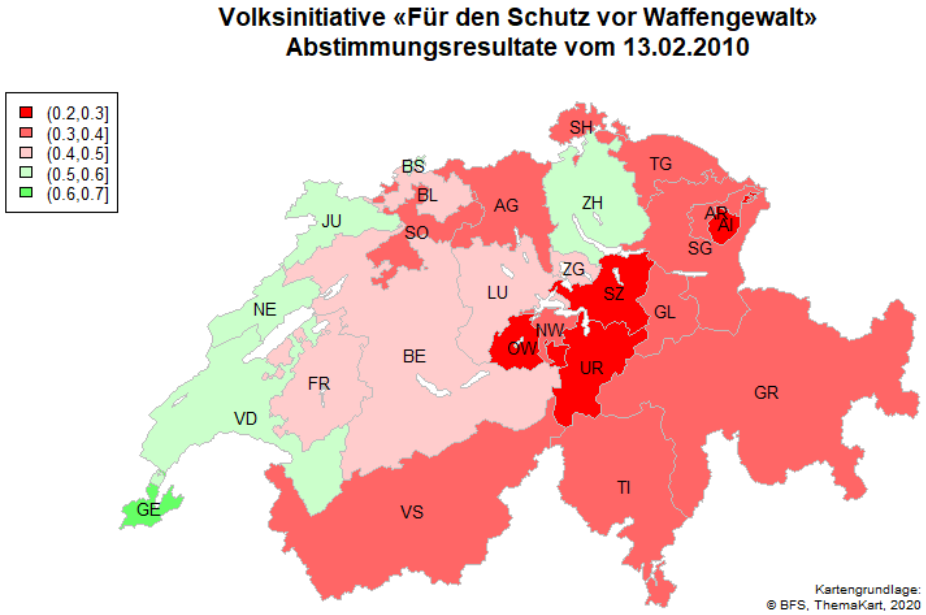
Plot of the cantons with display of their capitals. The coordinates of the capitals are stored in the file `stkt.pnt` and can be extracted with `stkt.pnt@coords`.
The chart is constructed so, that first the smallest spatial units (municipalities) are drawn, then the next larger ones (districts) and finally the top units (cantons). Capitals and waters are drawn over the map last.

```
RequireMap(c("polg.map", "bezk.map", "kant.map", "stkt.pnt"))

# Plot municipalities
plot(tkart$polg.map, border="grey85" )
plot(tkart$bezk.map, border="grey55", add=TRUE  )
plot(tkart$kant.map, border="black", lwd=1, add=TRUE )

AddLakes()
AddRivers()

# Capitals of cantons
points(tkart$stkt.pnt@coords, pch=21, col="grey", bg="red")
```

5 Numeric Based Colorcoding for Cantons

Plot of the cantons with a colour-coded variable and table in the same plot.

```
# Combine map with tabular results
waffen <- c(0.504,0.406,0.401,0.294,0.291,0.281,0.312,0.302,0.428,0.411,0.350,0.589,

0.452,0.390,0.378,0.277,0.392,0.350,0.386,0.345,0.365,0.537,0.381,0.532,0.610,0.520)
names(waffen) <- levels(d.bfsrg$kt_x)
cols <- colorRampPalette(c("red", "white", "green"), space = "rgb")(6)[
  cut(waffen, breaks=c(seq(0.2,0.8,0.1))) ]

layout( matrix(c(1,2), nrow=2, byrow=TRUE), heights=c(2,0.5), TRUE)

usr <- par(mar=c(0,4.1,4.1,2.1))
PlotKant(col=cols, main="Volksinitiative «Für den Schutz vor
Waffengewalt»\nAbstimmungsresultate vom 13.02.2010" )
text(tkart$kant.pnt, labels=unique(d.bfsrg$kt_x), cex=0.8)
legend(x="topleft", inset=0.02, cex=0.8,
       fill=colorRampPalette(c("red", "white", "green"), space = "rgb")(6)[1:5],
       legend=levels( cut(waffen, breaks=c(seq(0.2,0.8,0.1))))[1:5] )
par(usr)

usr <- par(mar=c(0,0,0,0))
out <- capture.output(round(waffen[1:13],3), round(waffen[14:26],3))
plot(1, axes=FALSE, frame.plot=FALSE, type="n", xlab="", ylab="" )
text(labels=out, x=1,
     y= 0.85 + rev(1:length(out)) * strheight( "S", cex=1.0 ) * 1.3,
      adj=c(0.5,0.5), family="mono", cex=0.8 )
par(usr)
layout(1)
```

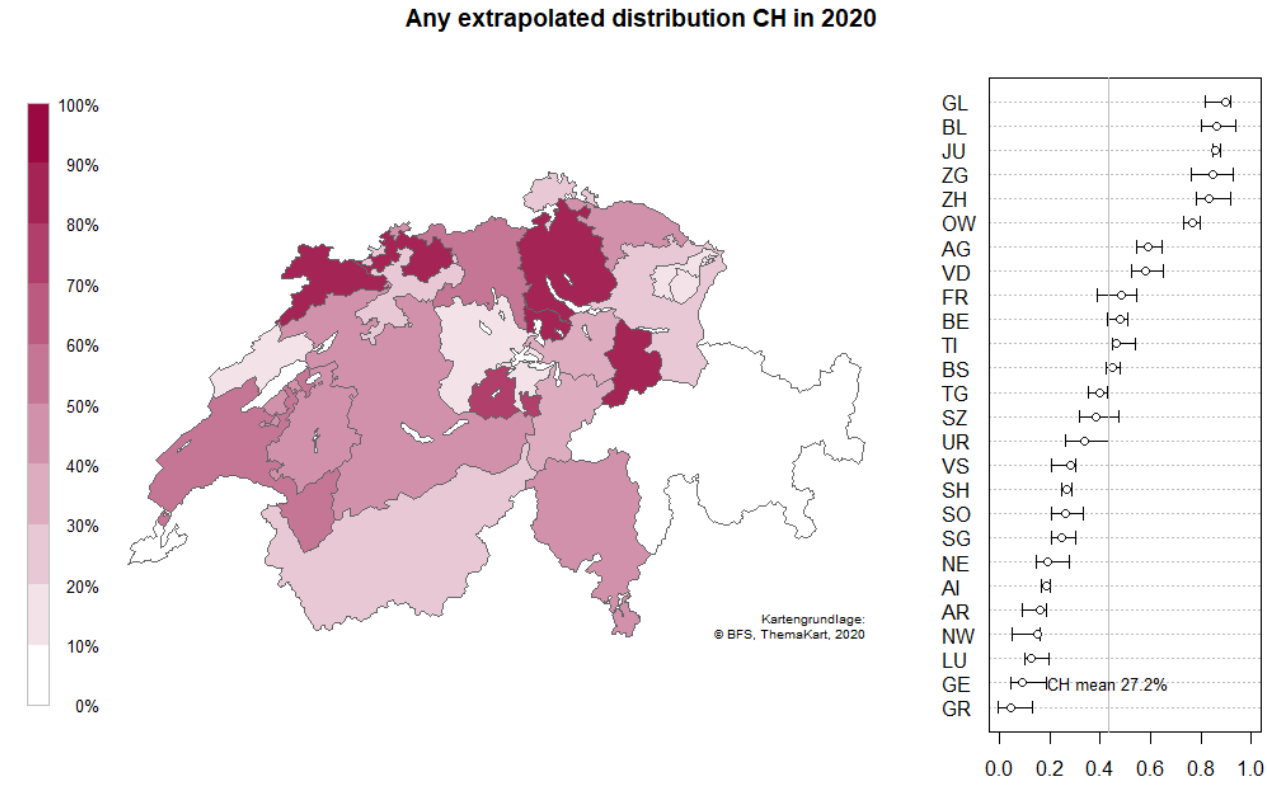



```
[1] 0.504 0.406 0.401 0.294 0.291 0.281 0.312 0.302 0.428 0.411 0.350 0.589 0.452
[1] 0.390 0.378 0.277 0.392 0.350 0.386 0.345 0.365 0.537 0.381 0.532 0.610 0.520
```

6 Combine Cantons with a Dotplot

A presentation of cantonal data that has proven to be very useful in practice is the simultaneous presentation of maps and a dotplot in which the numerical value to be depicted can be made well visible with possible confidence intervals. The graphic area is divided for this purpose with `layout()`. This process is encapsulated in the function `PlotMapDot()` and simplifies the coding.

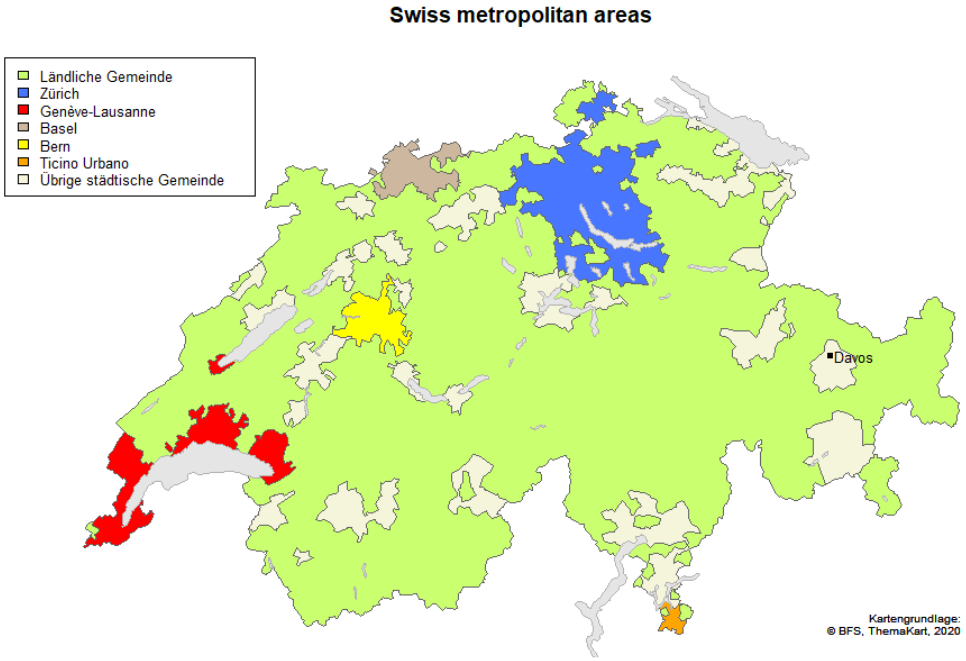
```
# get some proportions and simulated confidence intervals
set.seed(1964)
ptab <- data.frame(val=runif(n=26, max = 0.9))
ptab$lci <- ptab$val - runif(n = 26, 0.01, 0.1)
ptab$uci <- ptab$val + runif(n = 26, 0.01, 0.1)
rownames(ptab) <- kt

# prepare the layout for the map and the dotplot
PlotMapDot()

# define the a color ramp with 10 colors
cols <- colorRampPalette(colors = c("white", hred))(10)

PlotKant(rownames(ptab), col=FindColor(ptab$val, cols = cols, min.x=0, max.x=1),
border="grey40")
ColorLegend(x="left", width=10000, labels=paste(seq(0, 100, 10), "%", sep=""),
            cols=cols, cex=0.8, adj=c(1,0.5), frame="grey", inset=c(-0.09, 0))

ptab <- Sort(ptab, decreasing=TRUE)

PlotDot(ptab$val,labels = rownames(ptab),
        args.errbars = list(from=ptab$lci, to=ptab$uci, mid=ptab$val),
        cex=1, xlim=c(0, 1), bg="white", pch=21, col="grey10")

abline(v=mean(ptab$val), col="grey")
text(x=mean(ptab$val), y=2, "CH mean 27.2%", cex=0.8)
```



7 Metropolitan Regions

Plot metropolitan regions Switzerland.

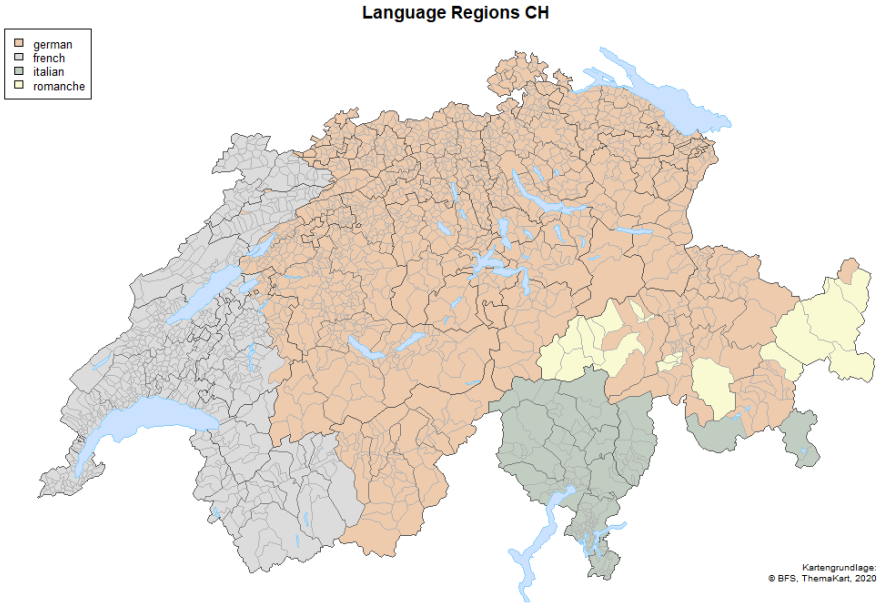
```
# Swiss metropolitan areas
RequireMap("metr.map")

tkart$metr.map@data$ID1 <-
  c("Ländliche Gemeinde", "Zürich", "Genève-Lausanne", "Basel", "Bern",
    "Ticino Urbano", "Übrige städtische Gemeinde")

# we have to prepare the background here, for some reasons...
PlotCH(col="beige", border=NA)
plot(tkart$metr.map, add=TRUE, border="grey40",

col=c("darkolivegreen1","royalblue1","red","bisque3","yellow","orange","wheat1")[as.n
umeric(tkart$metr.map@data$ID0)+1])
AddLakes(col="grey90", border="grey70")
legend( x="topleft", legend=tkart$metr.map@data$ID1,

fill=c("darkolivegreen1","royalblue1","red","bisque3","yellow","orange","beige"),
        bg="white", cex=0.8, xpd=TRUE )

title(main="Swiss metropolitan areas")
BfSStamp()

# Add some single points by coordinates
points(2782783,1185993,pch=15, cex=0.8 )
text(2782783,1185993," Davos", cex=0.8, adj=c(0,0.5) )
```



8 Language Regions

Display language regions or any other data from the attached recordset `d.bfsrg`.

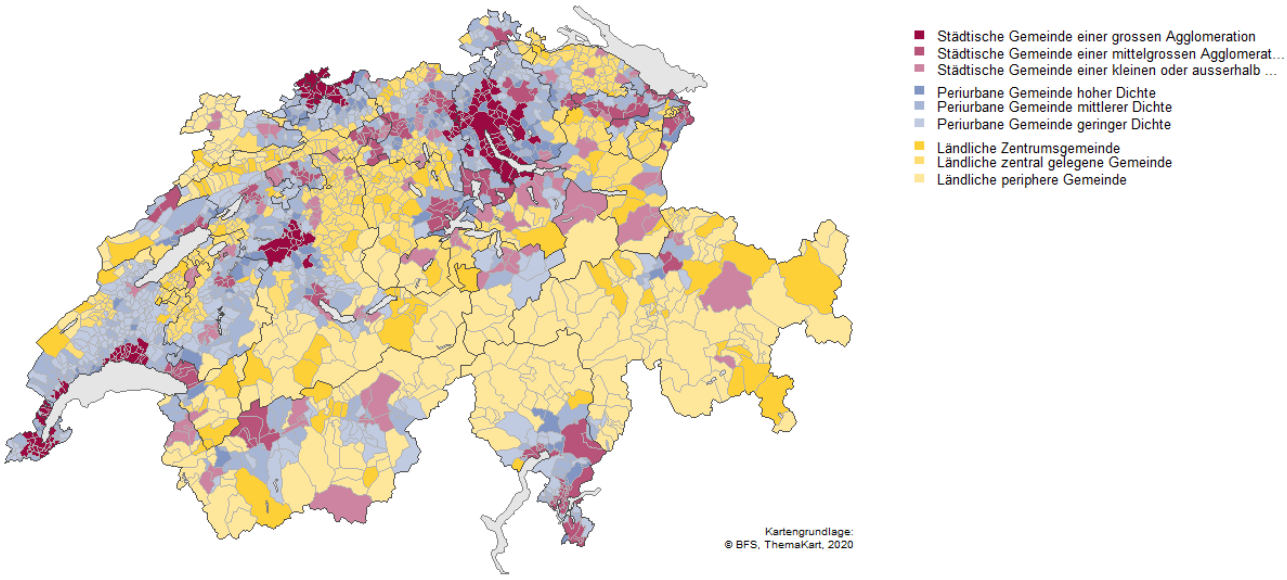
```
cols <- c("peachpuff2","gainsboro","honeydew3","lightgoldenrodyellow")

PlotPolg(d.bfsrg$bfs_nr, col=cols[d.bfsrg$sprgeb_c],
         border="grey70", main="Language Regions CH" )

RequireMap(c("bezk.map", "kant.map"))
plot(tkart$bezk.map, border="grey50", add=TRUE)
plot(tkart$kant.map, border="grey35", add=TRUE)


AddLakes(col="lightsteelblue1", border="lightskyblue" )
legend(x="topleft", legend=c("german", "french", "italian", "romanche"),
       bg="white", cex=0.8, fill=cols)
```



9 Community Types

We have several community types in Switzerland. Communities who show a high degree of urbanisation and such with more rural characteristics. The variable `gem_typ9_x` contains a grouping factor of 9 levels.

```
cols <- as.vector(sapply(c(hred, hblue, hyellow),
                         SetAlpha, alpha=c(1, 0.7, 0.5)))

Mar(right=20)
PlotPolg(id=d.bfsrg$gem_id, col=cols[as.numeric(d.bfsrg$gem_typ9_x)],
         border="grey70")
AddLakes(col="grey90", border="grey50")
PlotKant(add=TRUE, col=NA, border="grey30")

legend(x=2854724, y=1292274, fill=cols, border=NA, box.col=NA,
       y.intersp=c(1,1,1, 1.1,1.05,1.05, 1.1,1.07,1.07),
       legend=StrTrunc(levels(d.bfsrg$gem_typ9_x), 50),
       xjust=0, yjust=1, cex=0.8, xpd=NA)
```

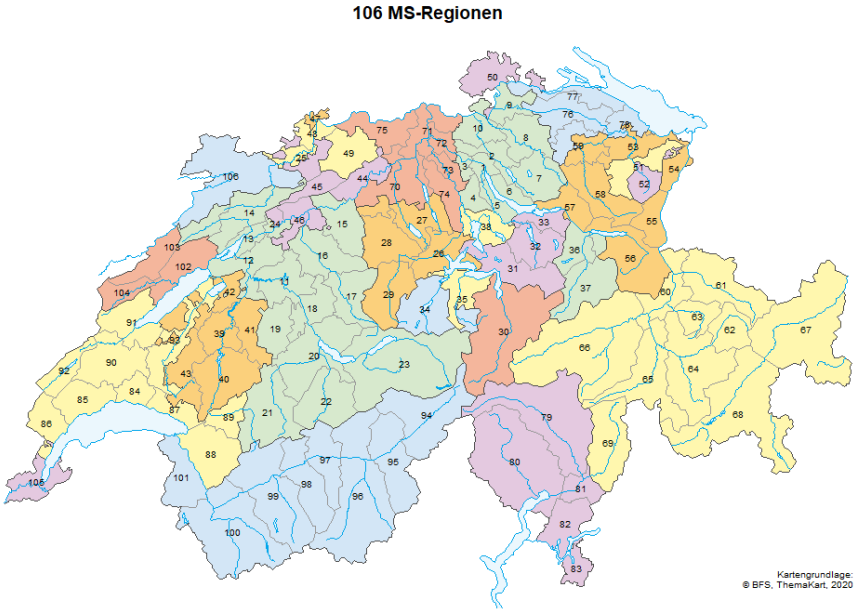


You might want to ask me about the y.intersp argument of the function legend. Please don't! I can't see neither a logic nor a sense. Apparently the argument is recycled, but in some peculiar sense.

10 MS-Regions

Plot MS Regions (‘mobilité spatiale’) in Switzerland, a special, artificial spatial partitioning of the Swiss Federal Statistical Office.

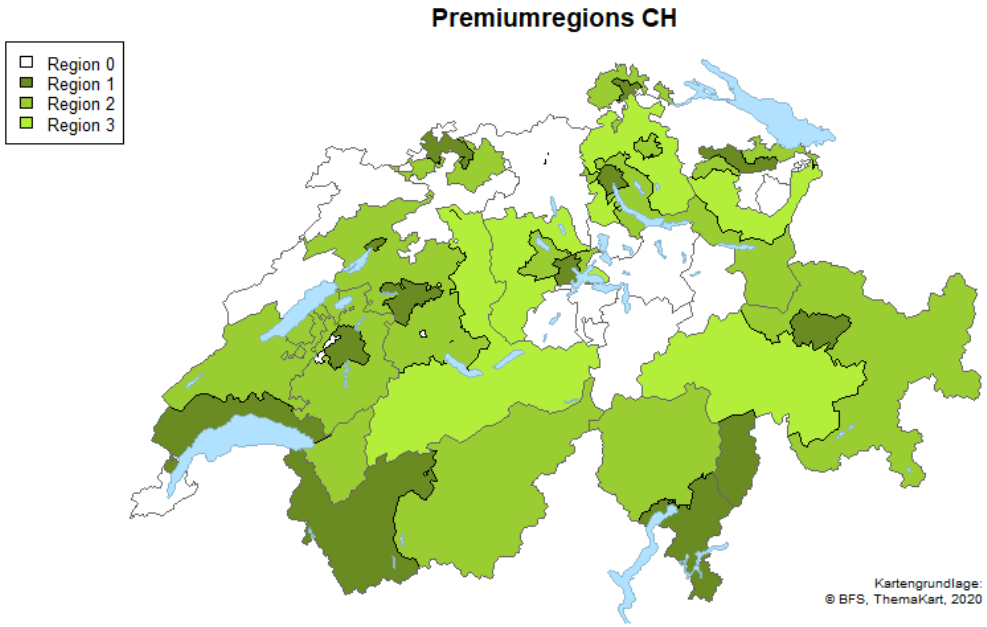
```
RequireMap(c("msre.map", "msre.pnt", "kant.map"))

cols <- c(y=rgb(255,247,174,max=255), o=rgb(251,208,124,max=255),
v=rgb(228,201,224,max=255),
          b=rgb(211,230,246,max=255), g=rgb(215,233,205,max=255),
r=rgb(244,182,156,max=255),
          p=rgb(255,248,236,max=255))

PlotKant(1:26, col=cols[c("g","g","o","r","v","b","y","g","y","o","v","o","y","v",
                          "y","v","o","y","r","b","v","y","b","r","v","b")],
         border="grey20", lwd=1, pbg=cols["p"], main="106 MS-Regions")

plot(tkart$msre.map, add=TRUE, border="grey60")
plot(tkart$kant.map, add=TRUE, border="grey30")

AddLakes(1:2, col=rgb(235,247,253, max=255), border=rgb(0,166,235,max=255))
AddRivers(1:5, col=rgb(0,166,235,max=255))

text(x=tkart$msre.pnt@coords[,1], y=tkart$msre.pnt@coords[,2],
     labels=tkart$msre.pnt@data$ID0, cex=0.6)
```



11 Premium Regions

For plotting the premium regions as own areas, we have first to combine the polygons of the municipalities. The data is made available by the Swiss Federal Office of Public Health FOPH – BAG. It is included in the internal dataset `d.bfsrg` of the package 'bfsMaps'.

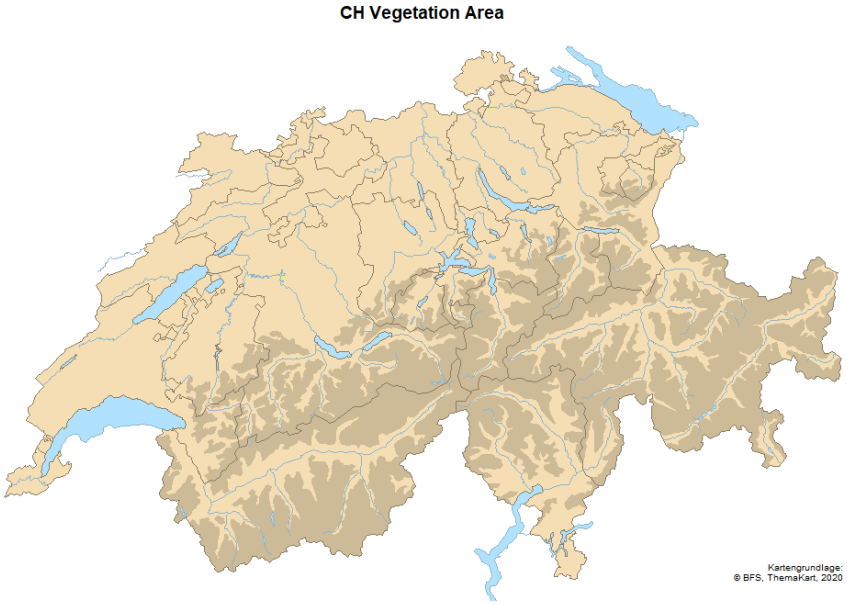
```
# start with a white the background
PlotCH(col="white", main="Premiumregions CH")

# Combine the municipalities to the premium regions
plot(CombinePolg(id=d.bfsrg$gem_id, g=d.bfsrg$preg_c),
     col=c("white","olivedrab4","olivedrab3","olivedrab2"), add=TRUE)

legend(x="topleft", fill=c("white","olivedrab4","olivedrab3","olivedrab2"),
       cex=0.8,
       legend=c("Region 0","Region 1","Region 2","Region 3") )

# overplot the canton borders
PlotKant(col=NA, border="grey40", add=TRUE)
# and add waters
AddLakes()
```



12 Vegetation Area

For the vegetation area, uninhabited, vegetation-free areas (lakes, glaciers, rock) are subtracted from the total area and not shown, thus achieving a more realistic spatial representation for most statistical results. In the map below the unfertile area is shown in dark.

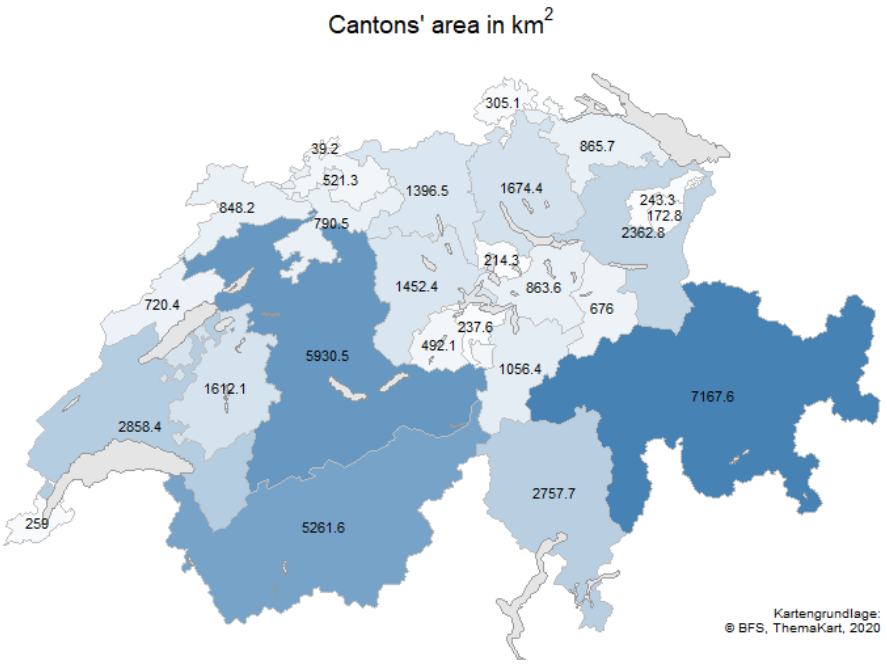
```
PlotCH(col="wheat3", col.vf="wheat", border="wheat3", main="CH Vegetation Area")
AddRivers()
AddLakes()
PlotKant(col=NA, border="wheat4", add=TRUE, lwd=1)
```



13 Further Information in shape-files

In the shape files you will find further information that can be extracted from the slots, however in a rather complicated way. Here is an example for the area of the cantons.

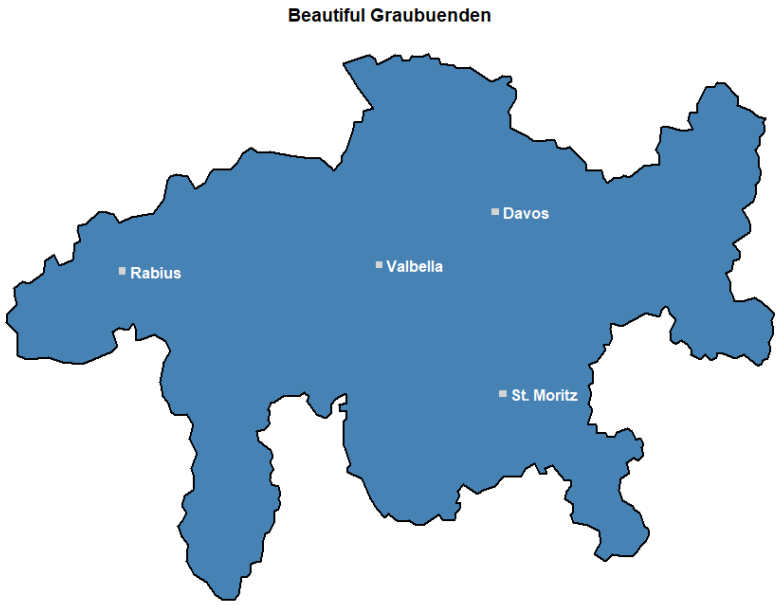
```
# Use data out of shape files slots (here: cantons' area)
acant <- sapply(slot(tkart$kant.map, "polygons"), function(x) slot(x, "area"))

# plot cantons
PlotKant(1:26, col=colorRampPalette(c("white", "steelblue"),
                                    space = "rgb")(720)[trunc(acant /10000000)],
         main= expression(paste( "Cantons' area in ", km^2)) )

AddLakes(col="grey90", border="grey60")

text(t(sapply( slot(tkart$kant.map, "polygons"), function(x) slot(x, "labpt"))),
     labels=round(acant/1E6,1), cex=0.7)
```



14 Single Cantons

We can also plot only single cantons.

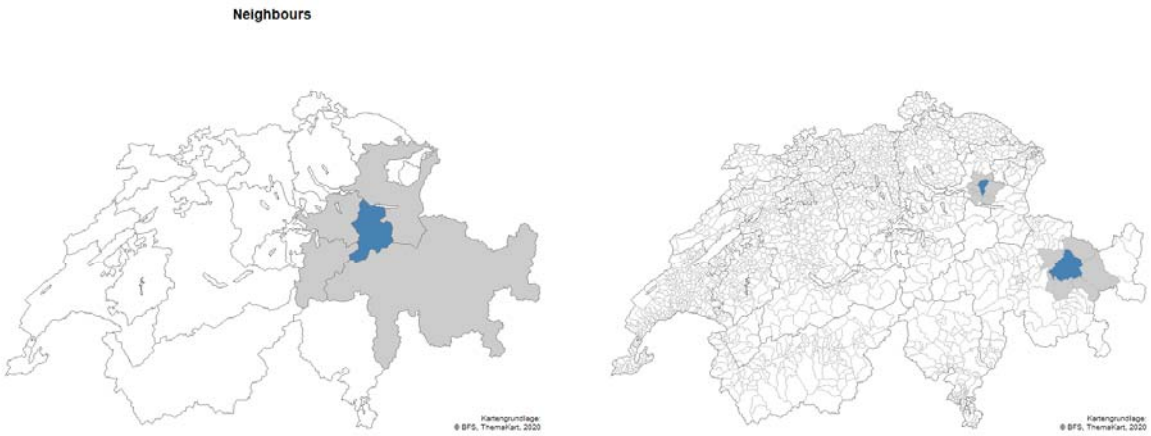
```
RequireMap("kant.map")

# Plot single cantons
kant.gr <- slot(tkart$kant.map,"polygons")[[18]]@Polygons[[1]]@coords

plot(kant.gr, asp=1, axes=FALSE, frame.plot=FALSE, type="n", xlab="", ylab="",
     main="Beautiful Graubuenden")

polygon(kant.gr, col="steelblue", lwd=2 )

loctext <- function(x, y, text){
  points(x, y, pch=15, col="lightgrey" )
  text(x, y, text, adj=c(0,0.5), col="white", font=2)
}

loctext(2782783,1185993,"  Davos")
loctext(2761412,1176112,"  Valbella")
loctext(2784192,1152424,"  St. Moritz")
loctext(2714275,1175027,"  Rabius")
```



15 Determine neighbours

To determine the neighbours adjacent to a region, the `Neighbours()` function can be used. The function requires the specification of the map and a vector with the IDs of the regions whose neighbours are to be determined. The result consists of a list. For each region a vector with the IDs of the direct neighbours is returned.

```
par(mfrow=c(1,2))

# Determine neighbours, here fort he canton Glarus (id=8)
nbs <- Neighbours(map=tkart$kant.map, id=8)[[1]]

PlotKant(c(8, nbs), col=c("steelblue", rep("grey80", length(nbs) )),
         main="Neighbours")
PlotKant(border="grey50", add=TRUE)
```



The determination is not limited to cantons but can be used with all spatial divisions. If neighbours are sought for several municipalities, several ids (municipality numbers) can be passed to the function as vectors. Also here `Neighbours()` returns the neighbours organized as a list.

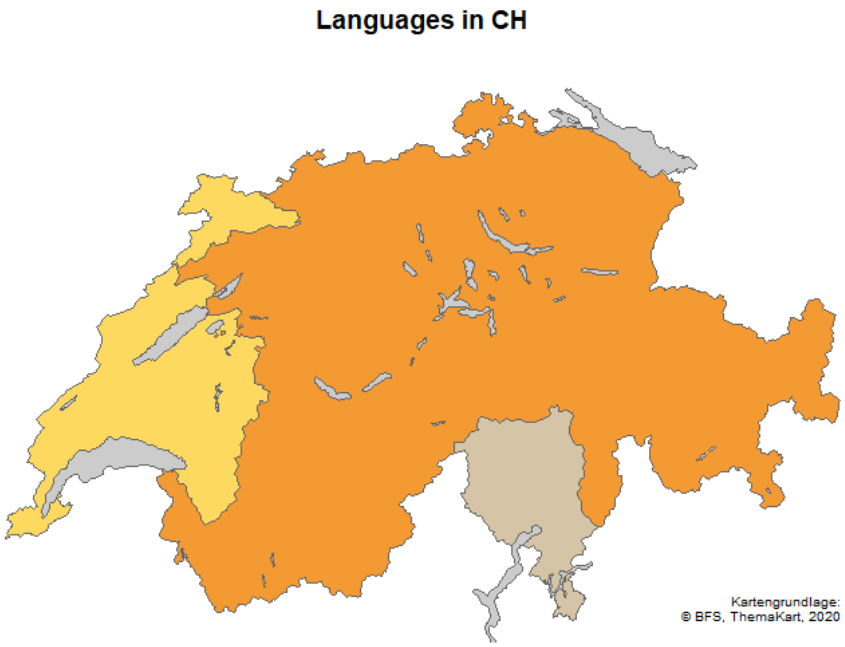
```
# works as well for communities and for a vector of ids
polg_id <- c(3851, 3352)
nbs <- Neighbours(tkart$polg.map, polg_id)

PlotPolg(c(polg_id, unlist(nbs)),
         col=c(rep("steelblue", 2), rep("grey80", length(unlist(nbs)))),
         border = "grey70")

PlotKant(border="grey50", add=TRUE)
```

16 Combining geographical areas

With the functions `CombinePolg()` and `CombineKant()`, cantonal or municipal areas can be combined into new units. This is useful, for example, for the display of premium regions or hospital service areas. Here it is sufficient to pass the region ID as an argument to the function and to provide grouping information for each region ID. The function then compiles the regions and returns them as plottable map objects.

The determination is not limited to cantons or municipalities, but can be done with all spatial divisions using the more general function `CombinePolygons()`.

```
# the language of the municipalities, aggregated by cantons

tkt <- table(d.bfsrg$kt_c, d.bfsrg$sprgeb_x)

# Group for the majority in the cantons
grp <- levels(d.bfsrg$sprgeb_x)[apply(tkt, 1, which.max)]

# Combine canton and plot them
plot(CombineKant(rownames(tkt), grp), col=SetAlpha(c(horange, hyellow, hecru), 0.8),
     border="grey40", main="Languages in CH")

# copyright is mandatory
BfSStamp()

# waters make the map more plastic...
AddLakes(col = "grey80", border = "grey40")
```



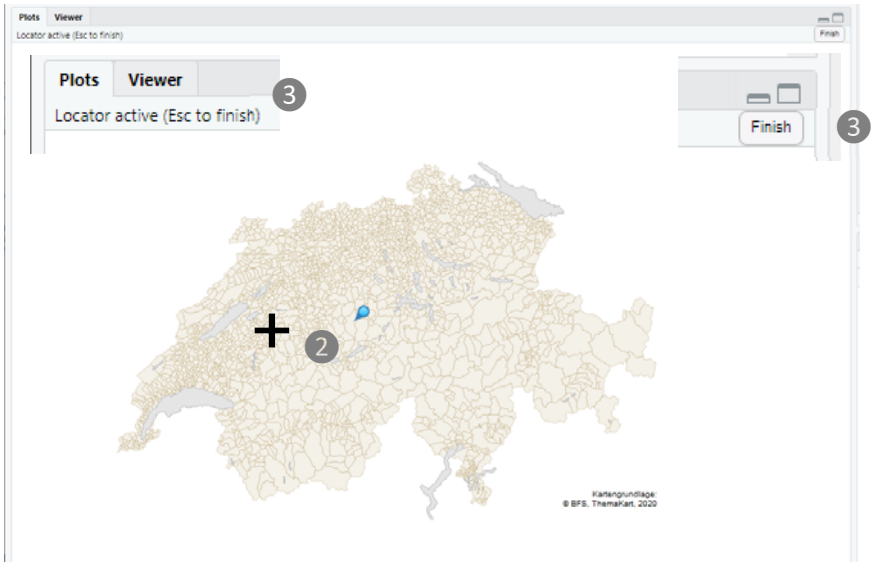
17 Swiss-Locator

Particularly in data cleansing at the municipal level, it happens that municipal areas remain white and one wants to know quickly which municipality(s) are involved.

The function `SwissLocator()` helps here. You can interactively click on any point on the CH map and get back information about the coordinates, canton and municipality affiliation etc. as a result.

```
# after having plotted a map, e.g. with PlotKant(), first start the locator
SwissLocator()

# ... the cursor changes to black cross +
```

[... then do some clicks on the map ...]



[... finish by pressing [ESC] or clicking on Finish ...]

The function reports the coordinates for the clicks, the according political community, the district, the MS-region and the canton. Coordinates outside the Swiss area will return as NA.

```
> SwissLocator()

Note: ------
  Found communities: 3732, 5049, 576.

        x       y gem_id  gemeinde_x              bezk_x       msre_x kt_x
1 2743318 1190791   3732       Flims             Imboden     Surselva   GR
2 2714675 1163682   5049      Blenio              Blenio    Tre Valli   TI
3 2642045 1167774    576 Grindelwald Interlaken-Oberhasli Oberland-Ost   BE
```

This resulting data frame will be stored in the bfsMaps own environment `tkart` under the name `tkart$found` , where it can be accessed subsequently.