Assignment 9: Mapping

Lydie Costes

OVERVIEW

This exercise accompanies the lessons in Water Data Analytics on mapping

Directions

1. Change "Student Name" on line 3 (above) with your name.
2. Work through the steps, **creating code and output** that fulfill each instruction.
3. Be sure to **answer the questions** in this assignment document.
4. When you have completed the assignment, **Knit** the text and code into a single PDF file.
5. After Knitting, check your PDF against the key and then submit your assignment completion survey at https://forms.gle/NDWEUu73LooFJPVM8

Having trouble? See the assignment's answer key if you need a hint. Please try to complete the assignment without the key as much as possible - this is where the learning happens!

Target due date: 2022-04-12

Setup

1. Load the tidyverse, LAGOSNE, maps, dataRetrieval, sf, and nhdplusTools packages. Set your ggplot theme (can be theme_classic or something else).

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.6     v dplyr   1.0.7
## v tidyr   1.1.4     v stringr 1.4.0
## v readr   2.1.1     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(dataRetrieval)
library(maps)
```

```
##
## Attaching package: 'maps'
```

```
## The following object is masked from 'package:purrr':
##
##     map
```

```
library(sf)
```

```
## Linking to GEOS 3.9.1, GDAL 3.4.0, PROJ 8.1.1; sf_use_s2() is TRUE
```

```
library(nhdplusTools)
```

```
## USGS Support Package: https://owi.usgs.gov/R/packages.html#support
```

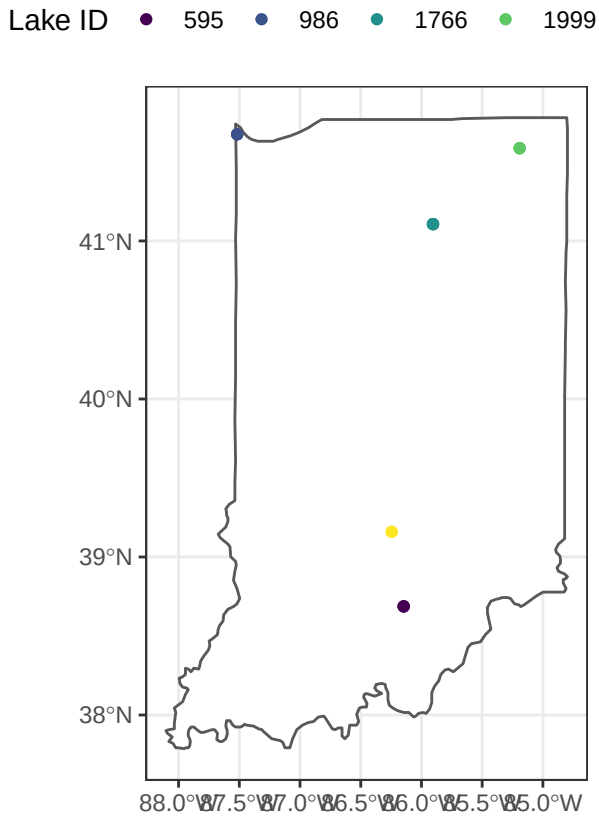
```
library(LAGOSNE)

theme_set(theme_bw())
options(scipen = 5)
```

LAGOS-NE

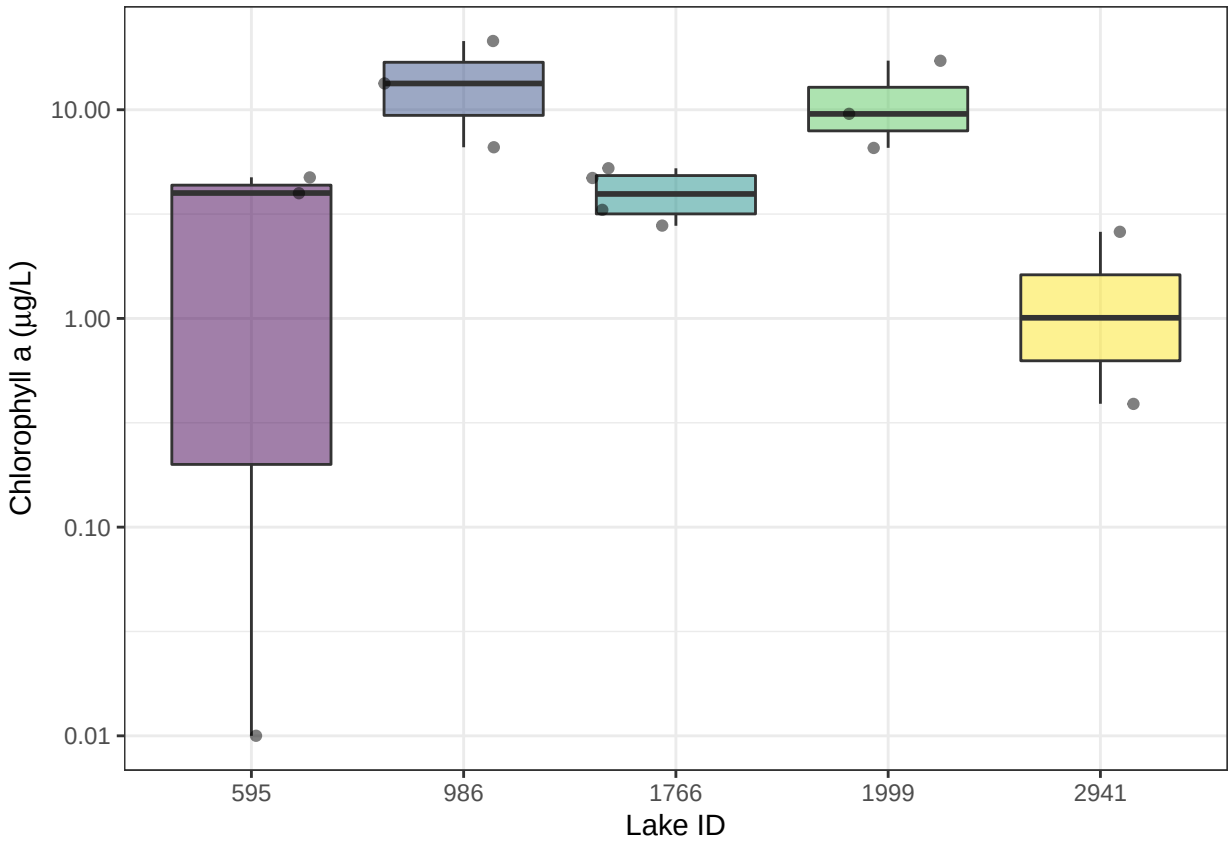
2. Choose five lakes in the LAGOS-NE database that are located within the same state and have chlorophyll data. Subset your data accordingly, and create two plots:

- A map of the five lakes within the state boundary, with each lake point as its own color.
- A boxplot with jittered points layered on top of chlorophyll concentrations in each lake (chlorophyll on y axis, lake on x axis), with each lake having a fill and/or color that matches the map.

```
# Load data and create datasets
LAGOSdata <- lagosne_load()
LAGOSlocus <- LAGOSdata$locus
LAGOSstate <- LAGOSdata$state
LAGOSnutrient <- LAGOSdata$epi_nutr

# create sf object to hold Indiana
states <- st_as_sf(map(database = "state", plot = FALSE, fill = TRUE, col = "white"))
states.subset <- filter(states, ID == "indiana")

# combine datasets and filter to Indiana
LAGOScombined <- left_join(LAGOSnutrient, LAGOSlocus) %>%
  left_join(., LAGOSstate) %>%
  filter(state == "IN") %>%
  select(lagoslakeid, sampledate, chla, nhd_lat, nhd_long) %>%
  drop_na(chla) %>%
  arrange(lagoslakeid)

# select sample of lakes
lakesample <- sample(x = LAGOScombined$lagoslakeid, size = 5)
LAGOSsample <- LAGOScombined %>%
  filter(lagoslakeid %in% lakesample)

# create sf object to hold lakes
LAGOSsample.spatial <- st_as_sf(LAGOSsample, coords = c("nhd_long", "nhd_lat"), crs = 4326)

# map lakes
ggplot() +
  geom_sf(data = states.subset, fill = "white") +
  geom_sf(data = LAGOSsample.spatial, aes(color = as.factor(lagoslakeid))) +
  scale_color_viridis_d() +
  labs(color = "Lake ID") +
  theme(legend.position = "top")
```




```
# graph CHLA levels for each lake
ggplot(LAGOSsample, aes(x = as.factor(lagoslakeid), y = chla, fill = as.factor(lagoslakeid))) +
  geom_boxplot(outlier.shape = NA, alpha = 0.5) +
  geom_jitter(alpha = 0.5) +
  scale_y_log10() +
  scale_fill_viridis_d() +
  labs(x = "Lake ID", y = expression("Chlorophyll a ("*mu*"g/L)"), fill = "") +
  theme(legend.position = "none")
```



NHDPlus

3. Delineate and map the watershed and flowpaths in the network upstream of the Eno River gage in Durham (USGS-02085070). Your map should include all stream orders.

```
# Recall there are a lot of parameters measured at the site
EnoParams <- whatNWISdata(siteNumbers = "02085070")

# Extract latitude and longitude for the site
EnoCoords <- EnoParams %>%
  select(site_no, dec_lat_va, dec_long_va) %>%
  distinct()

# Define the gage site as the starting point
start_point <- st_sfc(st_point(c(EnoCoords$dec_long_va, EnoCoords$dec_lat_va)),
                      crs = 4269) # NAD83, commonly  used by US agencies
start_comid <- discover_nhdplus_id(start_point)
# start_point2 <- st_as_sf(data.frame(x = NeuseCoords$dec_long_va, y =  NeuseCoords$dec_lat_va),
#                               coords = c("x", "y"), crs = 4269)

# Navigate the NLDI network
NLDI <- navigate_nldi(list(featureSource = "comid", featureID = start_comid),
                           mode = "upstreamTributaries",
                           distance_km = 1000)

# Extract watershed and flowpath information
subset_file <- tempfile(fileext = ".gpkg") # required step to run the subset_nhdplus function
```

```
subset <- subset_nhdplus(comids = as.integer(NLDI$UT$nhdplus_comid),
                         output_file = subset_file,
                         nhdplus_data = "download",
                         flowline_only = FALSE,
                         return_data = TRUE, overwrite = TRUE)
```

```
## All intersections performed in latitude/longitude.
```

```
## Reading NHDFlowline_Network
```

```
## Writing NHDFlowline_Network
```

```
## Reading CatchmentSP
```

```
## Writing CatchmentSP
```

```
## Warning: No nhdarea features found
```

```
# Create data frames
flowline <- subset$NHDFlowline_Network
catchment <- subset$CatchmentSP
waterbody <- subset$NHDWaterbody

class(flowline)
```

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

```
class(catchment)
```

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

```
class(waterbody)
```

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

```
# find gages near watershed
gages <- get_nwis(AOI = catchment) # AOI = Area of Interest
```

```
## Warning in if (AOI_type == "POINT") {: the condition has length > 1 and only the
## first element will be used
```

```
## Warning in if (AOI_type == "POINT") {: the condition has length > 1 and only the
## first element will be used
```

```
class(gages)
```

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

```
# find gages only within watershed
gages <- st_intersection(gages, catchment)
```

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

```
# ready made plot with basemap
plot_nhdplus("USGS-02085070", streamorder = 3)
```

```
## Found invalid geometry, attempting to fix.
```

```
## Warning: No nhdarea features found
```

```
## Warning in showSRID(uprojargs, format = "PROJ", multiline = "NO", prefer_proj =
## prefer_proj): Discarded ellps WGS 84 in Proj4 definition: +proj=merc +a=6378137
```

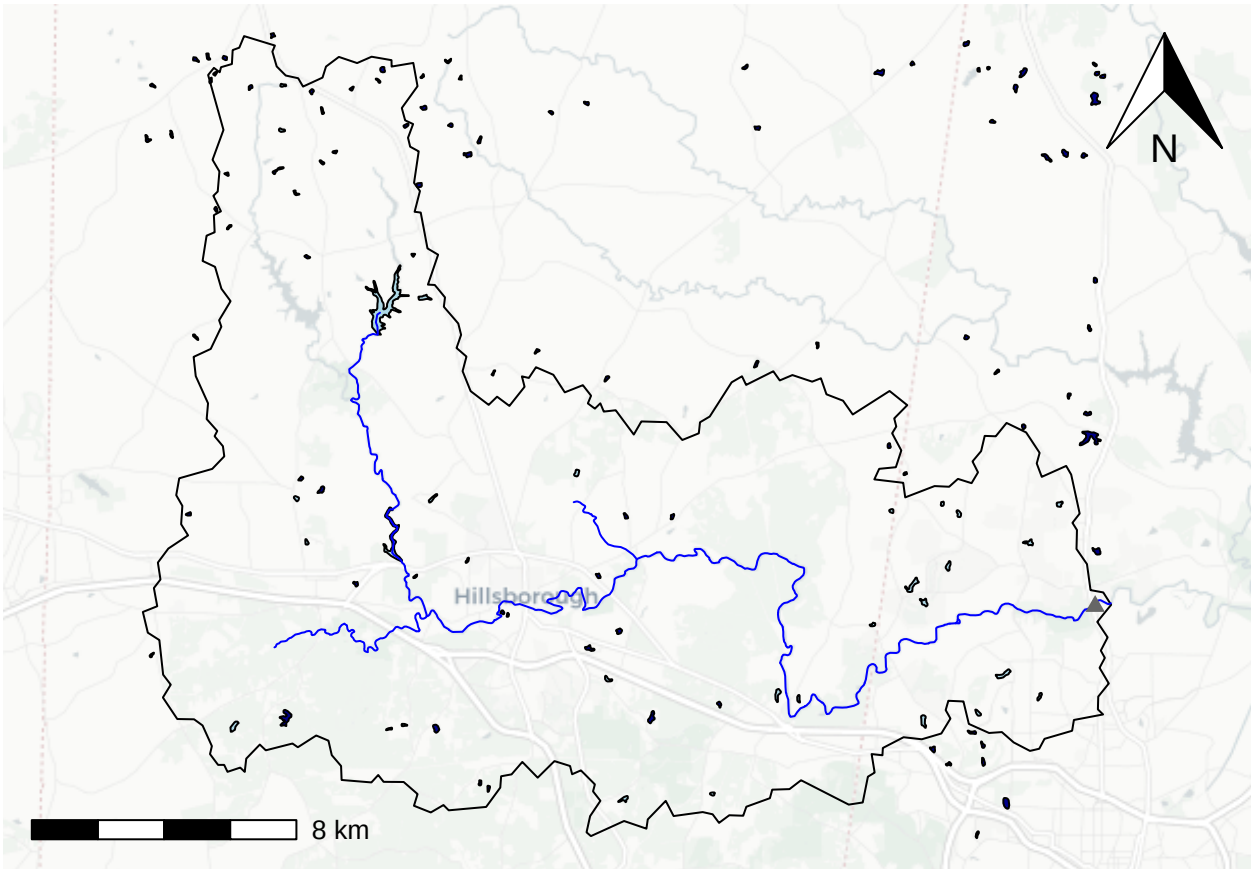
```
## +b=6378137 +lat_ts=0 +lon_0=0 +x_0=0 +y_0=0 +k=1 +units=m +nadgrids=@null
## +wktext +no_defs
```

```
## Warning in showSRID(uprojargs, format = "PROJ", multiline = "NO", prefer_proj =
## prefer_proj): Discarded datum WGS_1984 in Proj4 definition
```

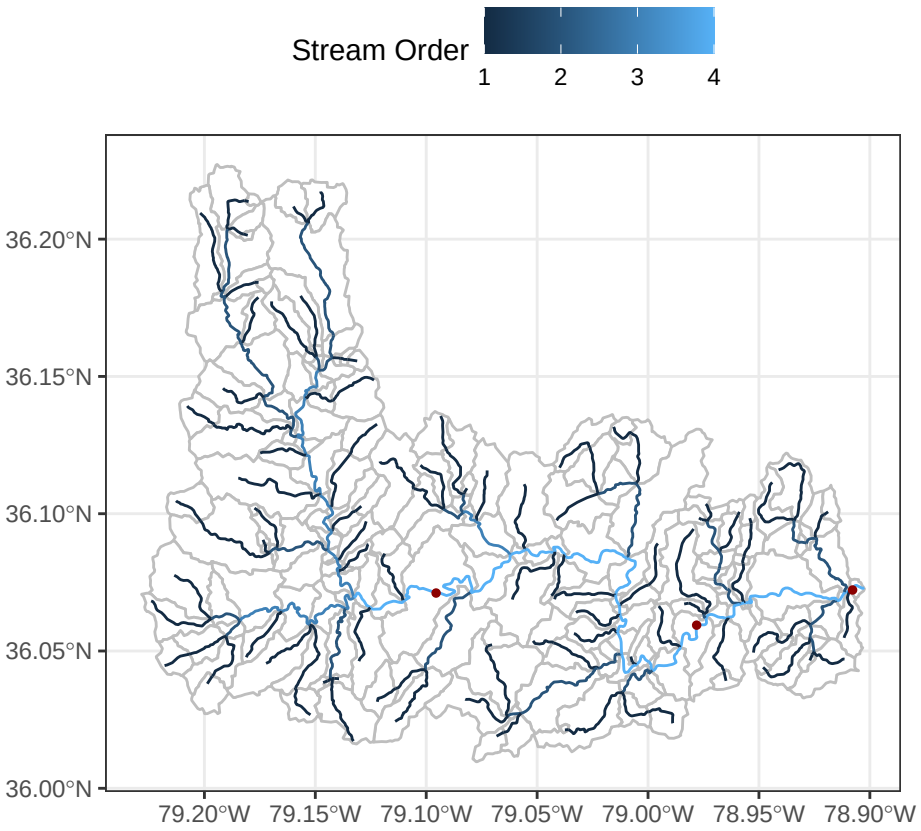
```
## Zoom: 11
```

```
## Map tiles by Carto, under CC BY 3.0. Data by OpenStreetMap, under ODbL.
```

```
## Audotdetect projection: assuming Google Mercator (epsg 3857)
```




```
ggplot(catchment) +
  geom_sf(fill = "white", color = "gray", lwd = 0.5) +
  geom_sf(data = flowline, aes(color = streamorde)) +
  geom_sf(data = gages, color = "darkred", size = 1) +
  labs(color = "Stream Order") +
  theme(legend.position = "top")
```




```
max(flowline$totdasqkm)
```

```
## [1] 367.6815
```

4. What is the upstream drainage area for this gage, and how are the flowpaths distributed with regard to stream order?

   The upstream area is 367.7 square kilometers. Water tends to flow from higher elevations to lower elevations, ending up in areas that are flatter, which will have higher stream order because of the water accumulation. 123 flowpaths of stream order 1, 45 of stream order 2, 19 of stream order 3, and 28 of stream order 4.

5. Are there any other gage sites in the upstream catchment? If so, where are they? > Yes, there are two other gages, one in Hillsborough and one at Cole Mill Road.