Assignment 10: Data Scraping

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Total points:

OVERVIEW

This exercise accompanies the lessons in Environmental Data Analytics on time series analysis.

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, submit the completed exercise (PDF file) to the dropbox in Sakai. Add your last name into the file name (e.g., "Salk_A06_GLMs_Week1.Rmd") prior to submission.

The completed exercise is due on Tuesday, April 7 at 1:00 pm.

Set up

1. Set up your session:

- Check your working directory
- Load the packages `tidyverse`, `rvest`, and any others you end up using.
- Set your ggplot theme

```
getwd()
```

```
## [1] "/Users/clairemullaney/Desktop/ENV 872/Environmental_Data_Analytics_2020"
```

```
library(tidyverse)
library(rvest)

# Set theme
ggtheme <- theme_classic(base_size = 14) +
  theme(axis.text = element_text(color = "black"),
        legend.position = "right")
theme_set(ggtheme)
```

2. Indicate the EPA impaired waters website (https://www.epa.gov/nutrient-policy-data/waters-assessed-impaired-due-nutr
as the URL to be scraped.

```
url <- "https://www.epa.gov/nutrient-policy-data/waters-assessed-impaired-due-nutrient-related-causes"

webpage <- read_html(url)
```

3. Scrape the Rivers table, with every column except year. Then, turn it into a data frame.

```
State <- webpage %>%
  html_nodes("table:nth-child(8) td:nth-child(1)") %>%
  html_text()
Rivers.Assessed.mi <- webpage %>%
  html_nodes("table:nth-child(8) td:nth-child(2)") %>%
```

```r
  html_text()
Rivers.Assessed.percent <- webpage %>%
  html_nodes("table:nth-child(8) td:nth-child(3)") %>%
  html_text()
Rivers.Impaired.mi <- webpage %>%
  html_nodes("table:nth-child(8) td:nth-child(4)") %>%
  html_text()
Rivers.Impaired.percent <- webpage %>%
  html_nodes("table:nth-child(8) td:nth-child(5)") %>%
  html_text()
Rivers.Impaired.percent.TMDL <- webpage %>%
  html_nodes("table:nth-child(8) td:nth-child(6)") %>%
  html_text()

Rivers <- data.frame(State, Rivers.Assessed.mi, Rivers.Assessed.percent,
                     Rivers.Impaired.mi, Rivers.Impaired.percent,
                     Rivers.Impaired.percent.TMDL)
```

4. Use `str_replace` to remove non-numeric characters from the numeric columns.
5. Set the numeric columns to a numeric class and verify this using `str`.

```r
# 4
Rivers$Rivers.Assessed.mi <- str_replace(Rivers$Rivers.Assessed.mi,
                                         pattern = "([,])", replacement = "")
Rivers$Rivers.Assessed.percent <- str_replace(Rivers$Rivers.Assessed.percent,
                                              pattern = "([%])", replacement = "")
Rivers$Rivers.Assessed.percent <- str_replace(Rivers$Rivers.Assessed.percent,
                                              pattern = "([*])", replacement = "")
Rivers$Rivers.Impaired.mi <- str_replace(Rivers$Rivers.Impaired.mi,
                                         pattern = "([,])", replacement = "")
Rivers$Rivers.Impaired.percent <- str_replace(Rivers$Rivers.Impaired.percent,
                                              pattern = "([%])", replacement = "")
Rivers$Rivers.Impaired.percent.TMDL <- str_replace(Rivers$Rivers.Impaired.percent.TMDL,
                                                   pattern = "([%])", replacement = "")
Rivers$Rivers.Impaired.percent.TMDL <- str_replace(Rivers$Rivers.Impaired.percent.TMDL,
                                                   pattern = "([±])", replacement = "")

# 5
str(Rivers)
```

```
## 'data.frame':    50 obs. of  6 variables:
##  $ State                       : Factor w/ 50 levels "Alabama","Alaska",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ Rivers.Assessed.mi          : chr  "10538" "602" "2764" "9979" ...
##  $ Rivers.Assessed.percent     : chr  "14" "0" "3" "11" ...
##  $ Rivers.Impaired.mi          : chr  "1146" "15" "144" "1440" ...
##  $ Rivers.Impaired.percent     : chr  "11" "2" "5" "14" ...
##  $ Rivers.Impaired.percent.TMDL: chr  "53" "100" "6" "2" ...
```

```r
Rivers$Rivers.Assessed.mi <- as.numeric(Rivers$Rivers.Assessed.mi)
Rivers$Rivers.Assessed.percent <- as.numeric(Rivers$Rivers.Assessed.percent)
Rivers$Rivers.Impaired.mi <- as.numeric(Rivers$Rivers.Impaired.mi)
Rivers$Rivers.Impaired.percent <- as.numeric(Rivers$Rivers.Impaired.percent)
Rivers$Rivers.Impaired.percent.TMDL <- as.numeric(Rivers$Rivers.Impaired.percent.TMDL)
```

```r
str(Rivers)
```

```
## 'data.frame':    50 obs. of  6 variables:
##  $ State                         : Factor w/ 50 levels "Alabama","Alaska",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ Rivers.Assessed.mi            : num  10538 602 2764 9979 32803 ...
##  $ Rivers.Assessed.percent       : num  14 0 3 11 16 56 41 100 20 19 ...
##  $ Rivers.Impaired.mi            : num  1146 15 144 1440 13350 ...
##  $ Rivers.Impaired.percent       : num  11 2 5 14 41 0 0 88 53 9 ...
##  $ Rivers.Impaired.percent.TMDL: num  53 100 6 2 NA 14 73 37 NA 78 ...
```

6. Scrape the Lakes table, with every column except year. Then, turn it into a data frame.

```r
State <- webpage %>%
  html_nodes("table:nth-child(14) td:nth-child(1)") %>%
  html_text()
Lakes.Assessed.acres <- webpage %>%
  html_nodes("table:nth-child(14) td:nth-child(2)") %>%
  html_text()
Lakes.Assessed.percent <- webpage %>%
  html_nodes("table:nth-child(14) td:nth-child(3)") %>%
  html_text()
Lakes.Impaired.acres <- webpage %>%
  html_nodes("table:nth-child(14) td:nth-child(4)") %>%
  html_text()
Lakes.Impaired.percent <- webpage %>%
  html_nodes("table:nth-child(14) td:nth-child(5)") %>%
  html_text()
Lakes.Impaired.percent.TMDL <- webpage %>%
  html_nodes("table:nth-child(14) td:nth-child(6)") %>%
  html_text()

Lakes <- data.frame(State, Lakes.Assessed.acres, Lakes.Assessed.percent,
                    Lakes.Impaired.acres, Lakes.Impaired.percent,
                    Lakes.Impaired.percent.TMDL)
```

7. Filter out the states with no data.

8. Use `str_replace` to remove non-numeric characters from the numeric columns.

9. Set the numeric columns to a numeric class and verify this using `str`.

```r
# 7
Lakes <- Lakes %>%
  filter(State != "Hawaii" & State != "Pennsylvania")


# 8
Lakes$Lakes.Assessed.acres<- str_replace(Lakes$Lakes.Assessed.acres,
                                         pattern = "([,])", replacement = "")
Lakes$Lakes.Assessed.acres <- str_replace(Lakes$Lakes.Assessed.acres,
                                          pattern = "([.])", replacement = "")
Lakes$Lakes.Assessed.percent <- str_replace(Lakes$Lakes.Assessed.percent,
                                            pattern = "([%])", replacement = "")
Lakes$Lakes.Assessed.percent <- str_replace(Lakes$Lakes.Assessed.percent,
                                            pattern = "([*])", replacement = "")
Lakes$Lakes.Impaired.acres <- str_replace(Lakes$Lakes.Impaired.acres,
```

```
                                          pattern = "([,])", replacement = "")
Lakes$Lakes.Impaired.percent <- str_replace(Lakes$Lakes.Impaired.percent,
                                              pattern = "([%])", replacement = "")
Lakes$Lakes.Impaired.percent.TMDL <- str_replace(Lakes$Lakes.Impaired.percent.TMDL,
                                                   pattern = "([%])", replacement = "")
Lakes$Lakes.Impaired.percent.TMDL <- str_replace(Lakes$Lakes.Impaired.percent.TMDL,
                                                   pattern = "([±])", replacement = "")

# 9
str(Lakes)
```

```
## 'data.frame':    48 obs. of  6 variables:
##  $ State                      : Factor w/ 50 levels "Alabama","Alaska",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ Lakes.Assessed.acres       : chr  "430976" "5981" "114976" "64778" ...
##  $ Lakes.Assessed.percent     : chr  "88" "0" "34" "13" ...
##  $ Lakes.Impaired.acres       : chr  "81740" "1137" "4895" "6513" ...
##  $ Lakes.Impaired.percent     : chr  "19" "19" "4" "10" ...
##  $ Lakes.Impaired.percent.TMDL: chr  "53" "73" "9" "71" ...
```

```
Lakes$Lakes.Assessed.acres <- as.numeric(Lakes$Lakes.Assessed.acres)
```

```
## Warning: NAs introduced by coercion
```

```
Lakes$Lakes.Assessed.percent <- as.numeric(Lakes$Lakes.Assessed.percent)
Lakes$Lakes.Impaired.acres <- as.numeric(Lakes$Lakes.Impaired.acres)
Lakes$Lakes.Impaired.percent <- as.numeric(Lakes$Lakes.Impaired.percent)
Lakes$Lakes.Impaired.percent.TMDL <- as.numeric(Lakes$Lakes.Impaired.percent.TMDL)

str(Lakes)
```

```
## 'data.frame':    48 obs. of  6 variables:
##  $ State                      : Factor w/ 50 levels "Alabama","Alaska",..: 1 2 3 4 5 6 7 8 9 10 ...
##  $ Lakes.Assessed.acres       : num  430976 5981 114976 64778 NA ...
##  $ Lakes.Assessed.percent     : num  88 0 34 13 50 95 47 100 54 82 ...
##  $ Lakes.Impaired.acres       : num  81740 1137 4895 6513 473954 ...
##  $ Lakes.Impaired.percent     : num  19 19 4 10 45 7 12 88 82 2 ...
##  $ Lakes.Impaired.percent.TMDL: num  53 73 9 71 NA 0 7 69 NA 20 ...
```

10. Join the two data frames with a `full_join`.

```
Rivers_Lakes <- full_join(Rivers, Lakes)
```

```
## Joining, by = "State"
```

11. Create one graph that compares the data for lakes and/or rivers. This option is flexible; choose a relationship (or relationships) that seem interesting to you, and think about the implications of your findings. This graph should be edited so it follows best data visualization practices.

(You may choose to run a statistical test or add a line of best fit; this is optional but may aid in your interpretations)

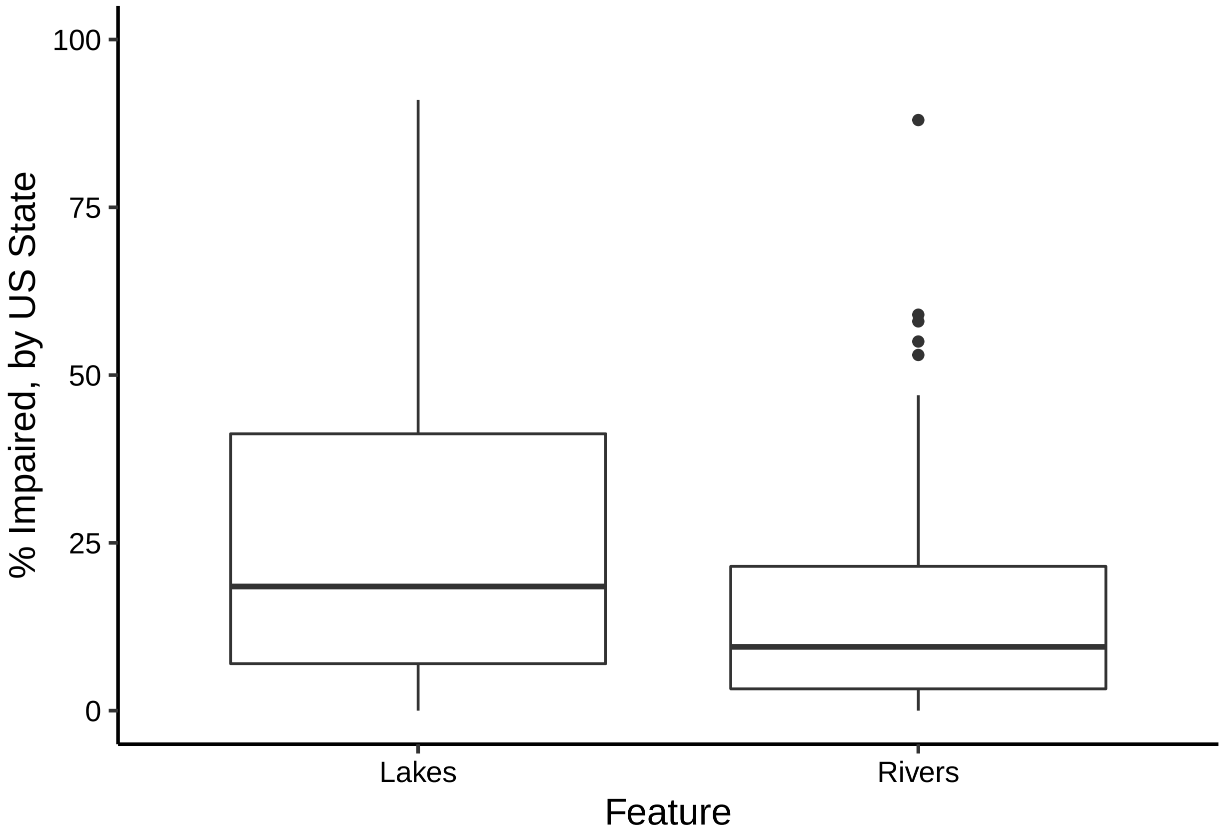
```
#Creating a gathered data frame to make a boxplot
Rivers_Lakes_boxplot <- Rivers_Lakes %>%
  select(State, Rivers.Impaired.percent, Lakes.Impaired.percent) %>%
  rename(Rivers = Rivers.Impaired.percent, Lakes = Lakes.Impaired.percent) %>%
  gather(Feature, Impaired.percent, -State)

#Make plot
```

```r
rivers_lakes_box <- ggplot(Rivers_Lakes_boxplot,
                   aes(y = Impaired.percent, x = as.factor(Feature))) +
  geom_boxplot() +
  labs(y = "% Impaired, by US State", x = "Feature") +
  ylim(0, 100)

print(rivers_lakes_box)
```

```
## Warning: Removed 2 rows containing non-finite values (stat_boxplot).
```




```r
#Calculations to aid in interpretation
summary(Rivers_Lakes$Rivers.Impaired.percent)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.00    3.25    9.50   17.42   21.50   88.00
```

```r
summary(Rivers_Lakes$Lakes.Impaired.percent, na.rm=TRUE)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##    0.00    7.00   18.50   28.19   41.25   91.00       2
```

```r
var.test(Rivers_Lakes_boxplot$Impaired.percent ~ as.factor(Rivers_Lakes_boxplot $Feature))
```

```
##
##  F test to compare two variances
##
## data:  Rivers_Lakes_boxplot$Impaired.percent by as.factor(Rivers_Lakes_boxplot$Feature)
## F = 2.0013, num df = 47, denom df = 49, p-value = 0.01756
## alternative hypothesis: true ratio of variances is not equal to 1
```

```
## 95 percent confidence interval:
##  1.130676 3.554481
## sample estimates:
## ratio of variances
##           2.00128
```

```
t.test(Rivers_Lakes_boxplot$Impaired.percent ~
         as.factor(Rivers_Lakes_boxplot $Feature), var.equal = FALSE)
```

```
##
##  Welch Two Sample t-test
##
## data:  Rivers_Lakes_boxplot$Impaired.percent by as.factor(Rivers_Lakes_boxplot$Feature)
## t = 2.182, df = 84.3, p-value = 0.03189
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##   0.9550311 20.5799689
## sample estimates:
##  mean in group Lakes mean in group Rivers
##              28.1875              17.4200
```

12. Summarize the findings that accompany your graph. You may choose to suggest further research or data collection to help explain the results.

    A boxplot comparing percentages of lakes and rivers impaired in states across the US shows that there is a greater median percentage of impaired lakes (18.5%) than impaired rivers (9.5%). The distributions of impaired percentages for both features are positively skewed, but the rivers data is less spread out, with a smaller IQR than the lakes data. These features of the boxplot suggest that the state percentages of impaired lakes range more widely than those of impaired rivers and that, overall, there are greater percentages of impaired lakes than rivers. A t-test confirms that the average percentage of impaired lakes is significantly greater than the average percentage of impaired rivers in US states ($t = 2.182$, $df = 84.3$, $p < 0.05$), indicating that US lakes may often need to be prioritized in nutrient-related preservation and restoration efforts.