

11: Crafting Reports

Environmental Data Analytics | John Fay & Luana Lima | Developed by Kateri Salk

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LESSON OBJECTIVES

1. Describe the purpose of using R Markdown as a communication and workflow tool
2. Incorporate Markdown syntax into documents
3. Communicate the process and findings of an analysis session in the style of a report

USE OF R STUDIO & R MARKDOWN SO FAR...

1. Write code
2. Document that code
3. Generate PDFs of code and its outputs
4. Integrate with Git/GitHub for version control

BASIC R MARKDOWN DOCUMENT STRUCTURE

1. **YAML Header** surrounded by `---` on top and bottom
 - YAML templates include options for html, pdf, word, markdown, and interactive
 - More information on formatting the YAML header can be found in the cheat sheet
2. **R Code Chunks** surrounded by `"on top and bottom" + Create using Cmd/Ctrl+Alt+I`
 - Can be named {r name} to facilitate navigation and autoreferencing
 - Chunk options allow for flexibility when the code runs and when the document is knitted
3. **Text** with formatting options for readability in knitted document

RESOURCES

Handy cheat sheets for R markdown can be found: [here](#), and [here](#).

There's also a quick reference available via the **Help**→**Markdown Quick Reference** menu.

Lastly, this website give a great & thorough overview.

THE KNITTING PROCESS



- The knitting sequence
- Knitting commands in code chunks:
- `include = FALSE` - code is run, but neither code nor results appear in knitted file
- `echo = FALSE` - code not included in knitted file, but results are

- `eval = FALSE` - code is not run in the knitted file
- `message = FALSE` - messages do not appear in knitted file
- `warning = FALSE` - warnings do not appear...
- `fig.cap = "..."` - adds a caption to graphical results

WHAT ELSE CAN R MARKDOWN DO?

See: <https://rmarkdown.rstudio.com> and class recording. * Languages other than R... * Various outputs...

WHY R MARKDOWN?

<Fill in our discussion below with bullet points. Use italics and bold for emphasis (hint: use the cheat sheets or **Help** → **Markdown Quick Reference** to figure out how to make bold and italic text).>

-allows users to better tailor their outputs to their needs -Rmarkdown allows you to combine paragraphs, code, and code outputs into one document -> this is very helpful for organizing -Coded results are documented and can be shared. this facilitates reproducibility and team work -markdown is free -can convert our RMD to pdf or word, while stata or other programs don't allow for that -its nice that if you change your plot, all you need to do is knit the file to update changes -you can import data and automatically update the data and everything depending on it -you can choose to run or display just parts of the analysis. You can omit some of the intermediate steps

TEXT EDITING CHALLENGE

Create a table below that details the example datasets we have been using in class. The first column should contain the names of the datasets and the second column should include some relevant information about the datasets. (Hint: use the cheat sheets to figure out how to make a table in Rmd)

Dataset_names	Dataset_information
ECOTOX_Neonicotinoids_Insects_Raw.csv	Data on neocotinoids and their effects on insects
EPAair_03_NC_2018(and2019).csv	Data from Air quality monitoring of and ozone
NEON_NIWO_Litter_massdata_Y-m_raw.csv	Data on Litterfall and Fine Woody Debris Sampling Data

R CHUNK EDITING CHALLENGE

Installing packages

Create an R chunk below that installs the package `knitr`. Instead of commenting out the code, customize the chunk options such that the code is not evaluated (i.e., not run).

```
install.packages("knitr")
```

Setup

Create an R chunk below called "setup" that checks your working directory, loads the packages `tidyverse`, `lubridate`, and `knitr`, and sets a ggplot theme. Remember that you need to disable R throwing a message, which contains a check mark that cannot be knitted.

```
getwd()
```

```
## [1] "/Users/courtneyannehorn/Desktop/EDA/EDAFin/Lessons"
```

```
library(tidyverse)
library(lubridate)
library(knitr)
library(rvest)
library(ggplot2)
```

```
theme_today <- theme_gray(base_size = 14) +
  theme(axis.text = element_text(color = "black"),
        legend.position = "top")
```

Load the NTL-LTER_Lake_Nutrients_Raw dataset, display the head of the dataset, and set the date column to a date format.

```
##   lakeid lakename year4 daynum sampledate depth_id depth tn_ug tp_ug nh34 no23
## 1      L Paul Lake 1991   140   5/20/91         1  0.00   538    25   NA   NA
## 2      L Paul Lake 1991   140   5/20/91         2  0.85   285    14   NA   NA
## 3      L Paul Lake 1991   140   5/20/91         3  1.75   399    14   NA   NA
## 4      L Paul Lake 1991   140   5/20/91         4  3.00   453    14   NA   NA
## 5      L Paul Lake 1991   140   5/20/91         5  4.00   363    13   NA   NA
## 6      L Paul Lake 1991   140   5/20/91         6  6.00   583    37   NA   NA
##   po4 comments
## 1   NA
## 2   NA
## 3   NA
## 4   NA
## 5   NA
## 6   NA

## [1] "Date"
```

Customize the chunk options such that the code is run but is not displayed in the final document.

Data Exploration, Wrangling, and Visualization

Create an R chunk below to create a processed dataset do the following operations:

- Include all columns except lakeid, depth_id, and comments
- Include only surface samples (depth = 0 m)
- Drop rows with missing data

```
colnames(Lake_nutrients_data)
```

```
## [1] "lakeid"      "lakename"    "year4"       "daynum"      "sampledate"
## [6] "depth_id"    "depth"       "tn_ug"       "tp_ug"       "nh34"
## [11] "no23"        "po4"         "comments"
```

```
Lake_nutrients_data_subset <- select(Lake_nutrients_data, lakename:sampledte, depth:po4) %>%
  filter(depth == 0) %>%
  drop_na()
```

```
#View(Lake_nutrients_data_subset)
```

Create a second R chunk to create a summary dataset with the mean, minimum, maximum, and standard deviation of total nitrogen concentrations for each lake. Create a second summary dataset that is identical except that it evaluates total phosphorus. Customize the chunk options such that the code is run but not displayed in the final document.

```
## [1] "lakename" "year4" "daynum" "sampledate" "depth"
## [6] "tn_ug" "tp_ug" "nh34" "no23" "po4"
```

Create a third R chunk that uses the function `kable` in the `knitr` package to display two tables: one for the summary dataframe for total N and one for the summary dataframe of total P. Use the `caption = " "` code within that function to title your tables. Customize the chunk options such that the final table is displayed but not the code used to generate the table.

Table 2: Nitrogen Summary Table

Lake Name	Total Nitrogen	Mean Nitrogen	Minimum Nitrogen	Maximum Nitrogen
Central Long Lake	690.0469	343.020	953.063	209.09341
Crampton Lake	362.6813	353.380	376.304	12.05748
East Long Lake	810.7834	380.620	2608.956	335.41457
Hummingbird Lake	1036.6695	779.053	1221.960	204.36889
Paul Lake	368.7564	45.670	628.625	106.34741
Peter Lake	561.8752	219.720	2048.151	305.64909
Tuesday Lake	423.5605	237.363	554.418	78.84522
West Long Lake	762.6017	303.170	2870.302	402.95992

Table 3: Phosphorus Summary Table

Lake Name	Total Phosphorus	Mean Phosphorus	Minimum Phosphorus
Central Long Lake	8.190	37.270	7.076388
Crampton Lake	5.803	15.555	4.946759
East Long Lake	8.000	101.050	17.375710
Hummingbird Lake	32.765	42.119	4.146717
Paul Lake	1.222	36.070	4.805142
Peter Lake	0.000	64.383	10.976205
Tuesday Lake	6.325	18.663	3.044289
West Long Lake	2.690	63.243	10.541276

Create a fourth and fifth R chunk that generates two plots (one in each chunk): one for total N over time with different colors for each lake, and one with the same setup but for total P. Decide which geom option will be appropriate for your purpose, and select a color palette that is visually pleasing and accessible. Customize the chunk options such that the final figures are displayed but not the code used to generate the figures. In addition, customize the chunk options such that the figures are aligned on the left side of the page. Lastly, add a `fig.cap` chunk option to add a caption (title) to your plot that will display underneath the figure.

Nitrogen Plot

Phosphorus Plot

Communicating results

Write a paragraph describing your findings from the R coding challenge above. This should be geared toward an educated audience but one that is not necessarily familiar with the dataset. Then insert a horizontal rule below the paragraph. Below the horizontal rule, write another paragraph describing the next steps you might take in analyzing this dataset. What questions might you be able to answer, and what analyses would you conduct to answer those questions?

I noticed from a visual inspection of my plots that the total nitrogen and phosphorus concentrations appear to differ between the lakes and the years. One thing that stood out to me was that there were high values of

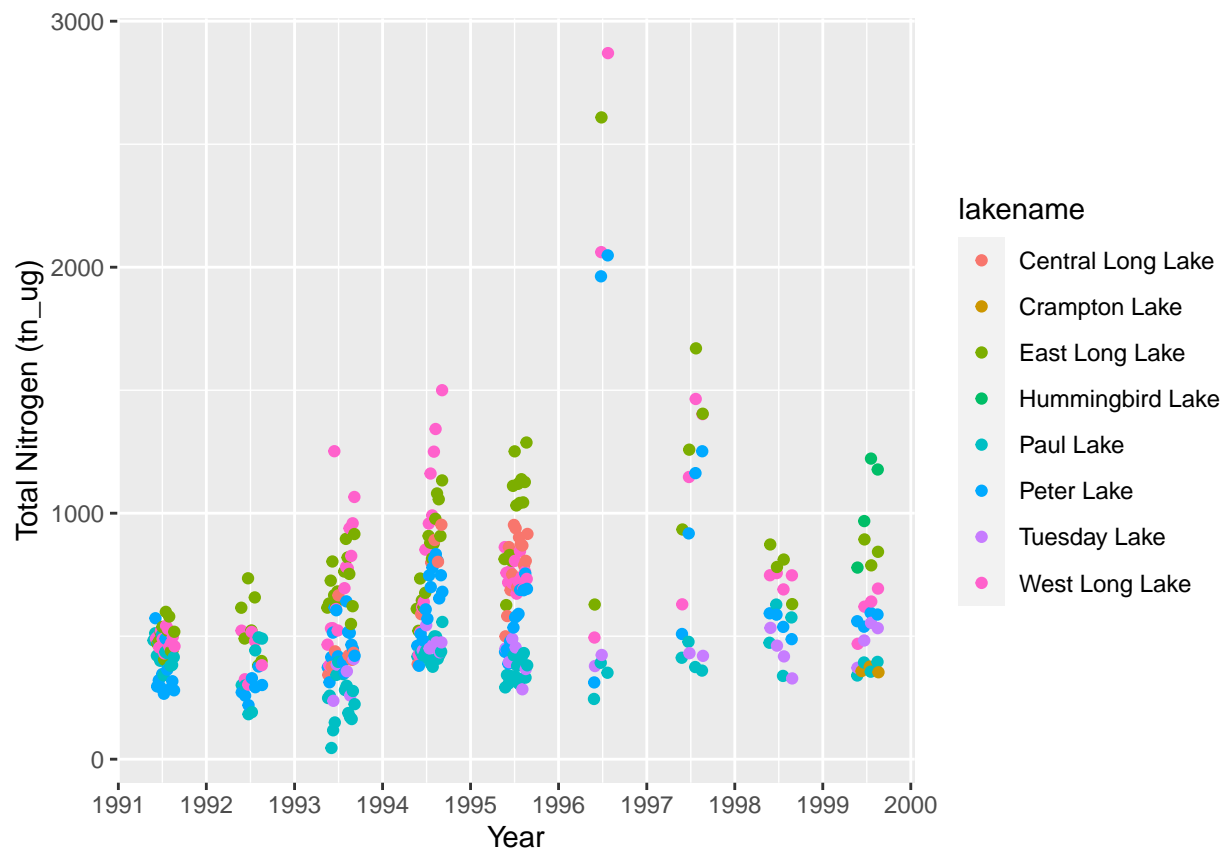


Figure 1: Total Nitrogen within lakes (1991 - 2000)

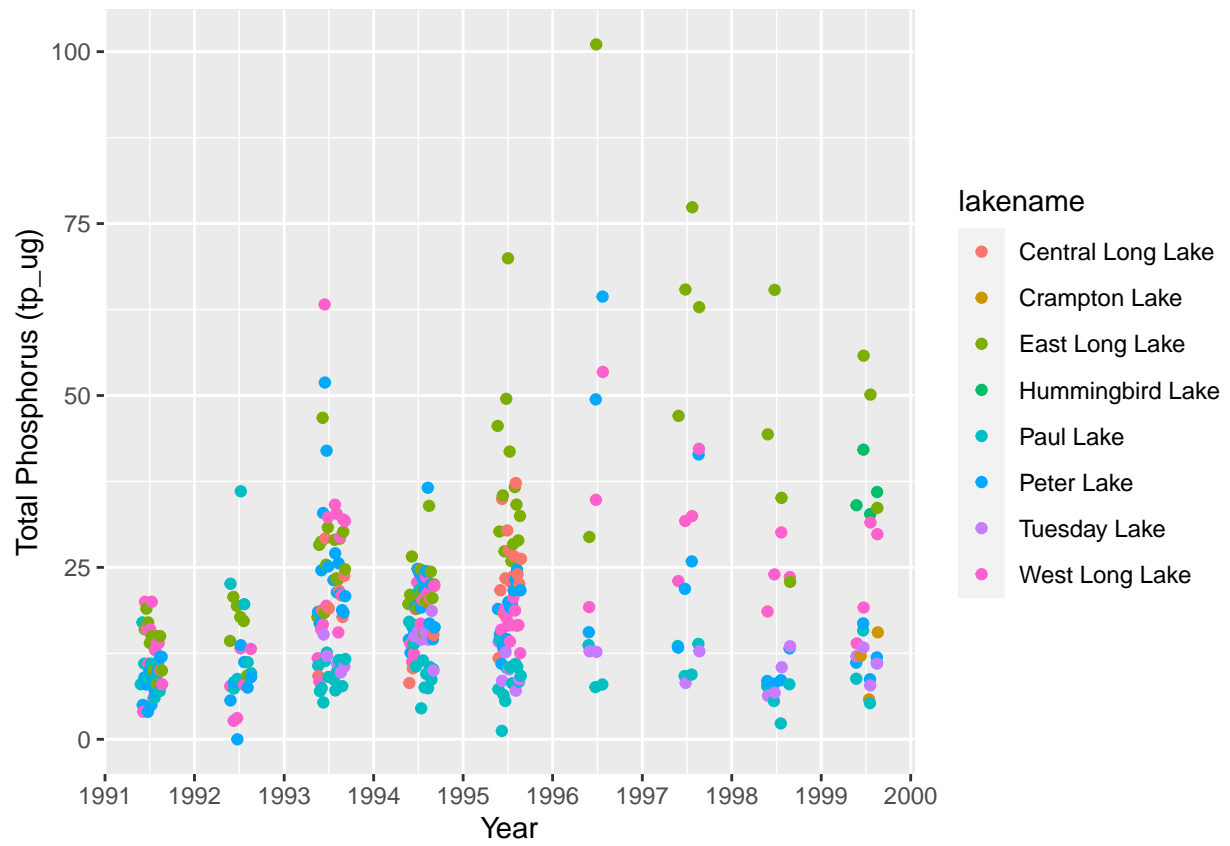


Figure 2: Total Phosphorus within lakes (1991 - 2000)

total Nitrogen in five of the lakes halfway through the year in 1996. These data points appear to be outliers since they stand out from the rest of the data points. Another noticeable aspect of the graphs is how East Long Lake has high values of total nitrogen and phosphorus in comparison to the other lakes each year and Tuesday Lake appears has relatively low Nitrogen values every year.

One of my next steps in analysis of the data would be looking into possible causes of the high nitrogen concentrations in 1996. I predict that a stochastic environmental phenomena may have caused the unusually high nitrogen concentrations in 5 of the lakes that year. I would also like to conduct anovas to analyze whether the mean nitrogen and phosphorus concentrations of the various lakes differ from each other significantly. I hypothesize that the mean nitrogen concentrations of East Long Lake and Tuesday Lake differ significantly.

KNIT YOUR PDF

When you have completed the above steps, try knitting your PDF to see if all of the formatting options you specified turned out as planned. This may take some troubleshooting.

OTHER R MARKDOWN CUSTOMIZATION OPTIONS

We have covered the basics in class today, but R Markdown offers many customization options. A word of caution: customizing templates will often require more interaction with LaTeX and installations on your computer, so be ready to troubleshoot issues.

Customization options for pdf output include:

- Table of contents
- Number sections
- Control default size of figures
- Citations
- Template (more info here)

```
pdf_document:  
toc: true  
number_sections: true  
fig_height: 3  
fig_width: 4  
citation_package: natbib  
template:
```