

11: Crafting Reports

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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).>

- R is **free** software
- Markdown allows for development of code output as something *other than* a .R code file.
- Better documentation of code and results, allowing for report-style writing without having to add paragraphs of commented-out code

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	Info
Ecotox Neonicotinoids	The dataset contains data from studies on several neonicotinoids and their effects insects, obtained from US EPA
EPA Air Quality Data	The dataset contains data from air quality monitoring of PM2.5 and ozone in North Carolina in 2017 and 2018
Neon Litter Data	The dataset contains data from monitoring at the Niwot Ridge Long-Term Ecological Research (LTER) station, comprising trap data for litter and small woody debris 2016-2019
NTL-LTER Lake Data	The dataset contains data from studies on several lakes in the North Temperate Lakes District in Wisconsin, USA. Data were collected as part of the Long Term Ecological Research station established by the National Science Foundation
Eno River USGS Data	The dataset contains streamflow data from the USGS streamflow gage site 02085000 (Eno River at Hillsborough, NC)

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.

```
knitr::opts_knit$set(root.dir = '/Users/analyselindborg/Desktop/Desktop - Analise's MacBook Pro/Data Analytics/Environmental_Dat',  
getwd())
```

```
## [1] "/Users/analyselindborg/Desktop/Desktop - Analise's MacBook Pro/Data Analytics/Environmental_Dat"
```

```
library(tidyverse)  
library(lubridate)  
library(knitr)  
  
theme <-  
  theme_bw() +  
  theme(panel.grid.minor = element_blank(),  
        panel.grid.major = element_blank(),  
        text = element_text(color = "black", size = 10),  
        axis.text.x = element_text(color = "black"),  
        axis.text.y = element_text(color = "black"))  
  
theme_set(theme)
```

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

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

```
##   lakeid lakename year4 daynum sampledte 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
```

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

```
NTL.subset <- NTL.data %>%
  select(-c("lakeid", "depth_id", "comments")) %>%
  filter(depth == 0) %>%
  drop_na()
```

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.

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: Summary data information for total nitrogen for all lakes at the Long Term Ecological Research station

Lake Name	Mean	Minimum	Maximum	St. Dev.
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: Summary data information for total phosphorus for all lakes at the Long Term Ecological Research station

Lake Name	Mean	Minimum	Maximum	St. Dev.
Central Long Lake	21.70981	8.190	37.270	7.076388
Crampton Lake	11.16033	5.803	15.555	4.946759
East Long Lake	29.28984	8.000	101.050	17.375710
Hummingbird Lake	36.21925	32.765	42.119	4.146717
Paul Lake	10.45606	1.222	36.070	4.805142
Peter Lake	18.39153	0.000	64.383	10.976205
Tuesday Lake	11.71853	6.325	18.663	3.044289
West Long Lake	19.82981	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.

I am using the subset data

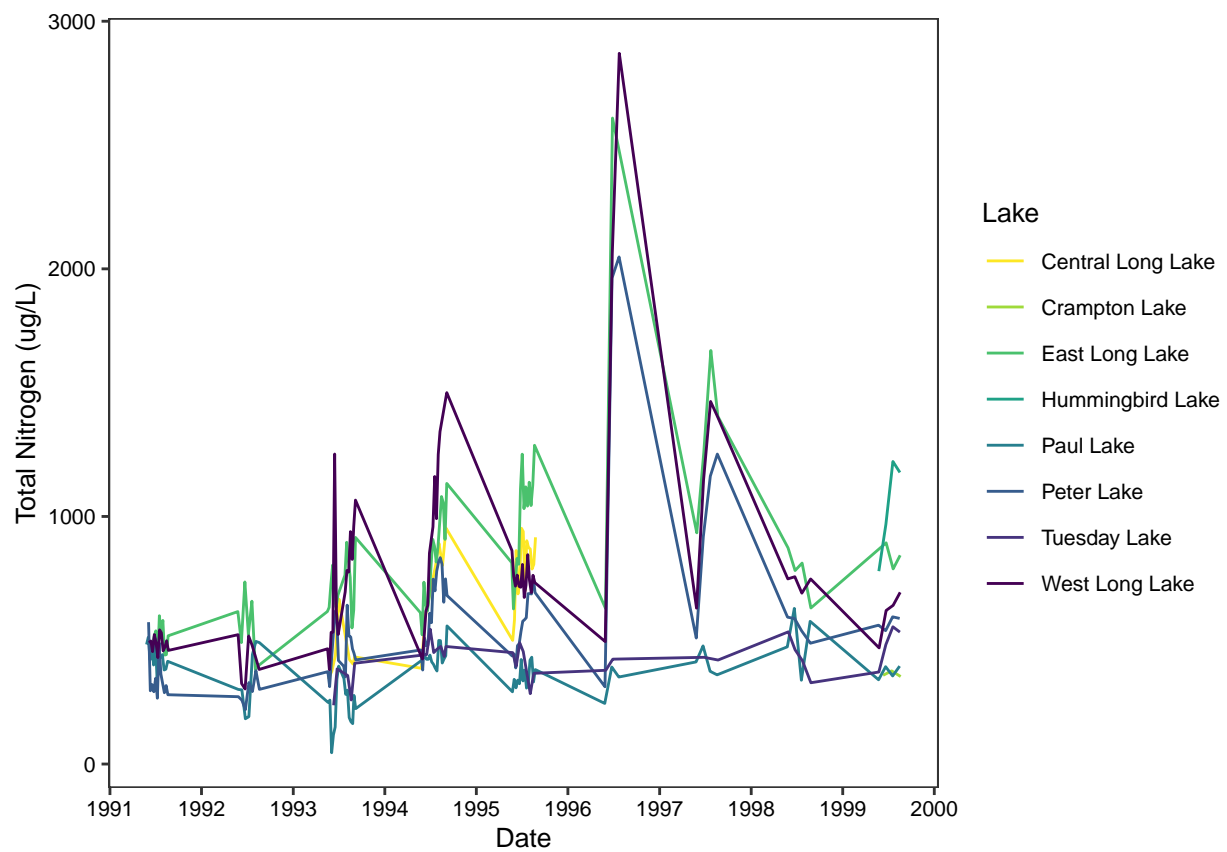


Figure 1: Total nitrogen concentrations (ug/L) over time for various lakes at the LTER station.

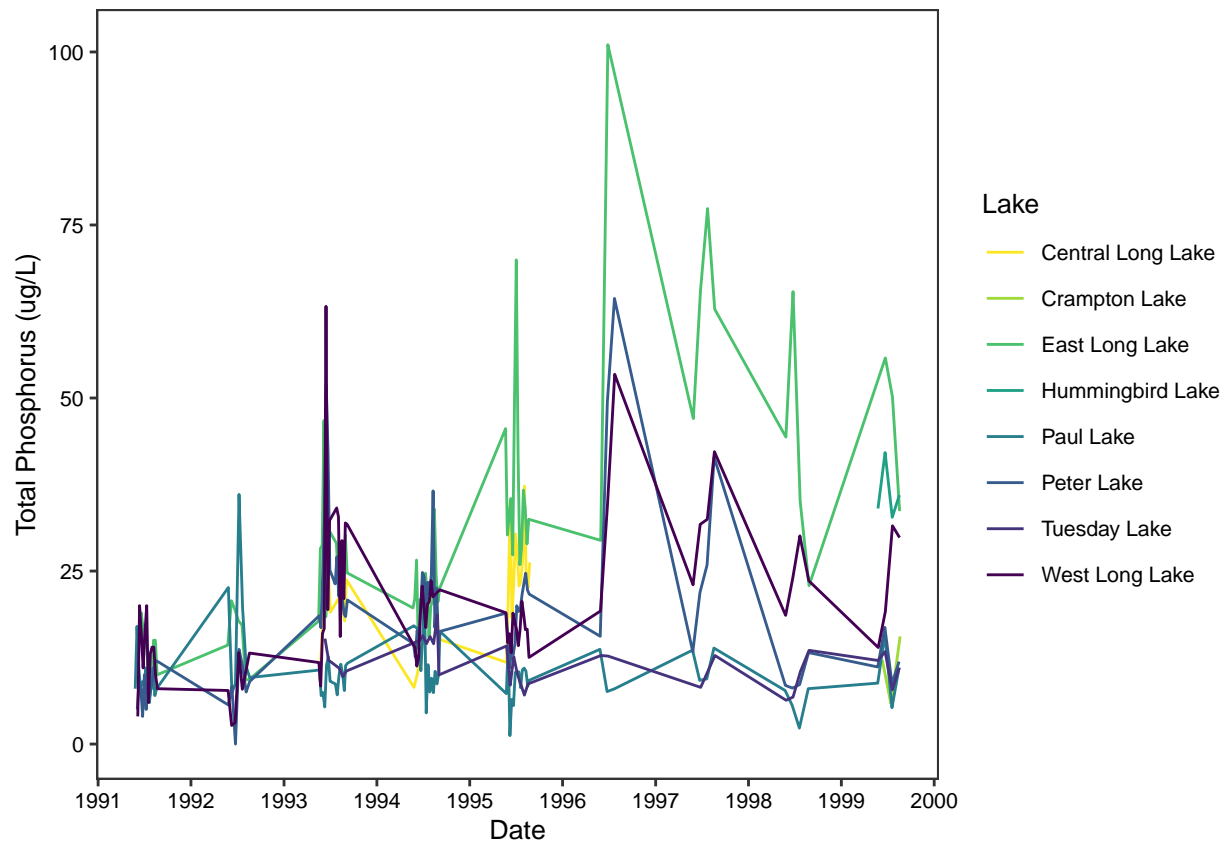


Figure 2: Total phosphorus concentrations (ug/L) over time for various lakes at the LTER station.

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?

Evaluation of total phosphorus and total nitrogen at various lakes at the Long Term Ecological Research Station primarily showed that there are differences between the lakes for these two parameters. Based on the figures, the concentrations vary over time, with both seasonal and yearly fluctuations. Generally, it appears that concentrations may increase from 1991-1997, then begin to decrease from 1997-2000. Additionally, total nitrogen concentrations appear to be higher than total phosphorus concentrations. Large gaps in data make trend determinations difficult.

Next steps for analysis could include time series analyses to determine changes in TP and TN over time for the individual lakes. Analyses could also include ANOVA tests to determine if any lakes differ from the rest with regards to concentrations of TP and TN. Linear regressions could also reveal whether TP and TN are correlated (e.g. if TN increases for a given site in a given year, does TP also increase?). Summary data would also be helpful for the individual years, instead of all years combined.

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: