11: Crafting Reports

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```
#Fixing the knitting error
#update.packages(ask = FALSE, checkBuilt = TRUE)
#tinytex::tlmgr_update()
```

```
#tinytex::reinstall_tinytex()
```

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 Markdown is limited to ~~one language~~ **many languages**

It allows us to take notes and write code on the same document, there is a combination of information and code that is available with R Markdown Especially when combined with GitHub, R Markdown is really great for collaboration, others can pull my code and hopefully edit it with relative ease *Knitting allows you to integrate the output of your code directly into your report, that way we don't have to re-write our report each time we change our output* The debugging process is much easier when we can split the code up by section

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)

Data Set Names	Relevant Information
EPAair_O3	Ozone information from the EPA in NC
EPAair_PM25	PM2.5 information from the EPA in NC
NEON_NIWO_Litter	Information on the litter on the ground in various different location

Data Set Names	Relevant Information
NTL-LTER_Lake	Information on various lakes in the NC regarding depth, clarity, etc.
NWIS_SiteFlowData	Information on the depths of various rivers at various times

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/benculberson/Documents/Duke /Spring 2022/Environmental Data Analytics/Environmental_Data
```

```
library(tidyverse)
```

```
## Warning: package 'tidyr' was built under R version 4.0.5
```

```
## Warning: package 'readr' was built under R version 4.0.5
```

```
## Warning: package 'dplyr' was built under R version 4.0.5
```

```
library(lubridate)
library(knitr)
```

```
## Warning: package 'knitr' was built under R version 4.0.5
```

```
mytheme <- theme_classic() +
  theme(axis.text = element_text(color = "black"),
        legend.position = "top")
theme_set(mytheme)
```

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.

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

```
Data <- Data %>%
  select(lakename:sampledate, depth:po4) %>%
  filter(depth == 0) %>%
  na.omit()
```

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: Nitrogen Summaries for Each Lake

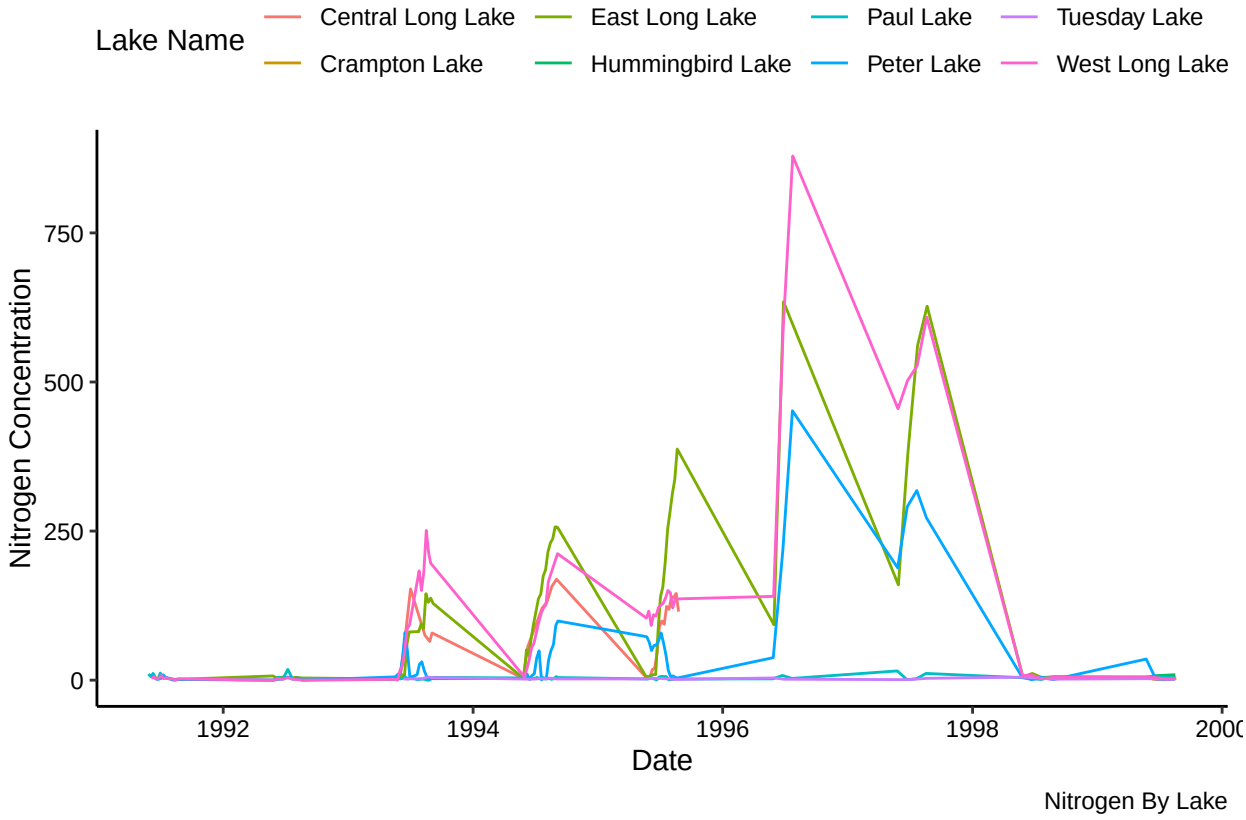
lakename	meanNitrogen	minimumNitrogen	maximumNitrogen	stdevNitrogen
Central Long Lake	83.697481	1.832	169.274	54.499435
Crampton Lake	1.639667	0.631	2.651	1.010003
East Long Lake	107.040315	0.427	634.587	147.530437
Hummingbird Lake	7.504750	5.013	9.112	1.775485
Paul Lake	3.686810	0.000	18.060	3.294013
Peter Lake	41.468372	0.000	451.758	80.049647
Tuesday Lake	2.578067	0.841	5.554	1.089038
West Long Lake	113.402556	0.000	878.939	166.426599

Table 3: Phosphorus Summaries for Each Lake

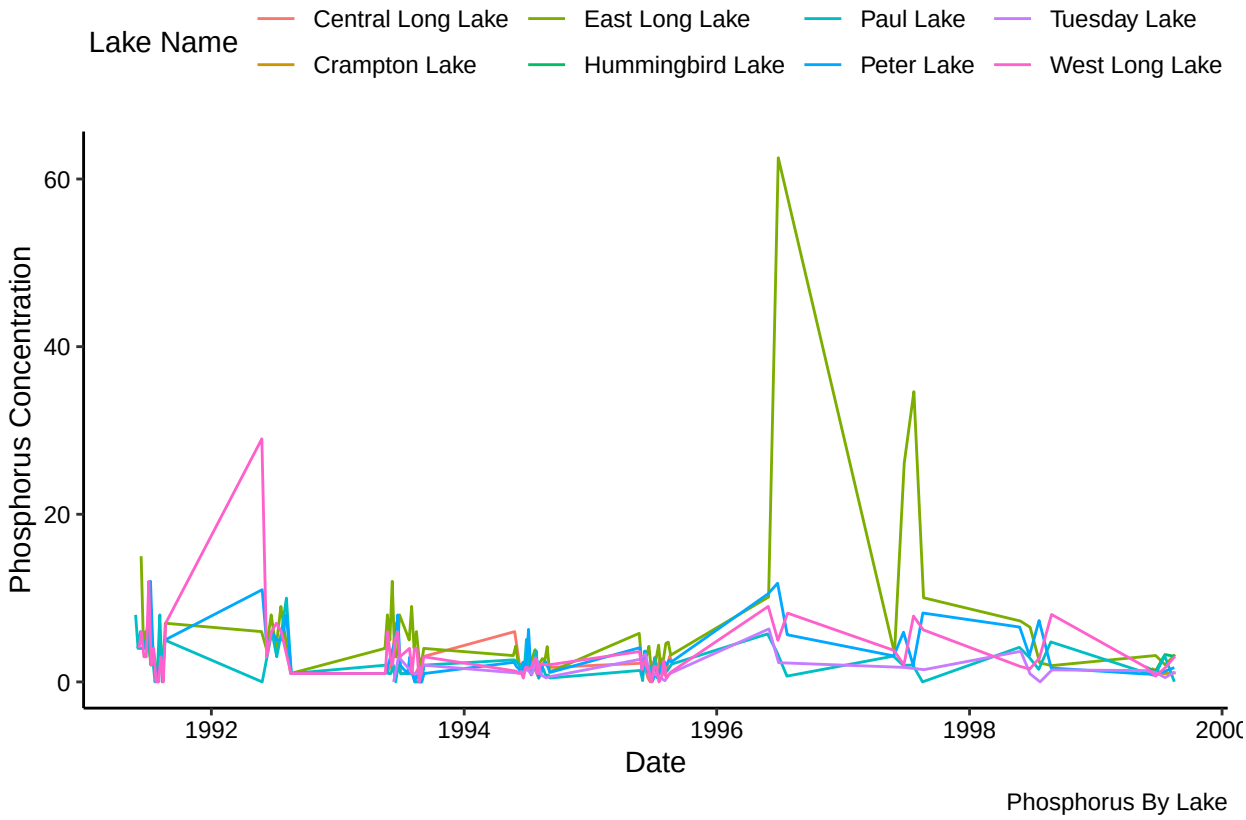
lakename	meanPhosphorus	minimumPhosphorus	maximumPhosphorus	stdevPhosphorus
Central Long Lake	2.124889	0.000	7.000	1.5182339
Crampton Lake	1.226667	0.983	1.608	0.3344702
East Long Lake	5.743630	0.000	62.535	8.4669011
Hummingbird Lake	2.335750	1.240	3.263	0.9744100
Paul Lake	2.276544	0.000	10.000	2.1335013
Peter Lake	3.175346	0.000	12.000	2.8039453
Tuesday Lake	1.524300	0.000	6.324	1.3136693
West Long Lake	3.331083	0.000	29.000	3.9450956

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 By Lake



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?

As we can see in the above two plots, the Nitrogen and Phosphorus concentrations of these 8 lakes vary over time. Some lakes clearly show more variation than others and furthermore, and Nitrogen concentrations seem to vary more than Phosphorus concentrations. Furthermore, there appears to be a significant spike in Nitrogen concentrations in 3 out of the 8 lakes in 1997-1998 and a spike in Phosphorus concentrations in East Long Lake at around the same time. Perhaps there was some exogenous event that caused this spike in concentrations.

The next steps we might take in analyzing this dataset include running a correlation matrix between the Nitrogen concentrations of the lakes and the Phosphorus concentrations of the lakes to see if there's some kind of relationship between these two concentrations. If we suspect a significant relationship, we can also run a GLM model to see if there is one. While we wouldn't know if this relationship is causal without more data, we could determine the size of the relationship.

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: