LAB 02

ENVX1002

THE UNIVERSITY OF SYDNEY

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Academic integrity

This exercise encourages students to discuss academic integrity, and in particular the grey areas often present. Your demonstrator will provide you with a number of scenarios to discuss with each other in smaller groups, and then with the class.

If you are interested in more information on Academic Integrity at the University of Sydney, see the following link: Academic Integrity. Also ensure you have completed the Academic Honesty Education Module (AHEM). This must be complete before your first assessment is due (next week for ENVX1002).

> Tip
>
> **Learning Outcomes**
> At the end of this practical students should be able to:
>
> - Use R to calculate simple summary statistics
> - Create basic plots using default R and ggplot
> - Develop your coding and Quarto skills
> - Do basic data wrangling using dplyr
> - Produce your own knitted Markdown document

Computer lab

We are going to be working through a series of tasks and also complete some exercises indicated by **Exercise**. The best way to do this is to create a project for this week, open a *Quarto* document and work through the tasks and complete the exercises. Each time document your answers/notes so that when you revisit the prac during your study for the mid-semester skills based assessment and final exam. You should have a good understanding of the code, the analysis, and what the meaning of the output is.

Setting up your project

The first step is to 1) create a new project folder for this weeks computer lab, 2) Move the data file **ENVX1002_Data2.xlsx** into your project folder, 3) start a new Quarto Document.

Plotting the tutorial water Quality Data - continued

- We will start with further describing the SO_4 water quality data
- Remember the most common way to enter data into R is to import it from an external file. Like in the tutorial, in this example we will import the data found in the worksheet called *SO4* found in the ENVX1002_Data2.xlsx file that can be downloaded from the Tutorial and Computer Lab Page on Canvas.
- In R you can import the file as a data frame using the `read_excel` function from the **readxl** package. Note that you need to specify which worksheet you want to import. If you have not installed the readxl package you will need to run `install.packages("readxl")` but you need to only run this once. Hence, I often suggest to simply type this in the console window bottom left in R Studio and run it from there or you can put a comment # in front after you have run the code once! Note that there are other commands, such as `read.csv` and `read.table`, that can be used to read in various files types!

```
# install.packages(readxl)
library(readxl)
water<-read_excel("ENVX1002_Data2.xlsx", sheet = "SO4")
```

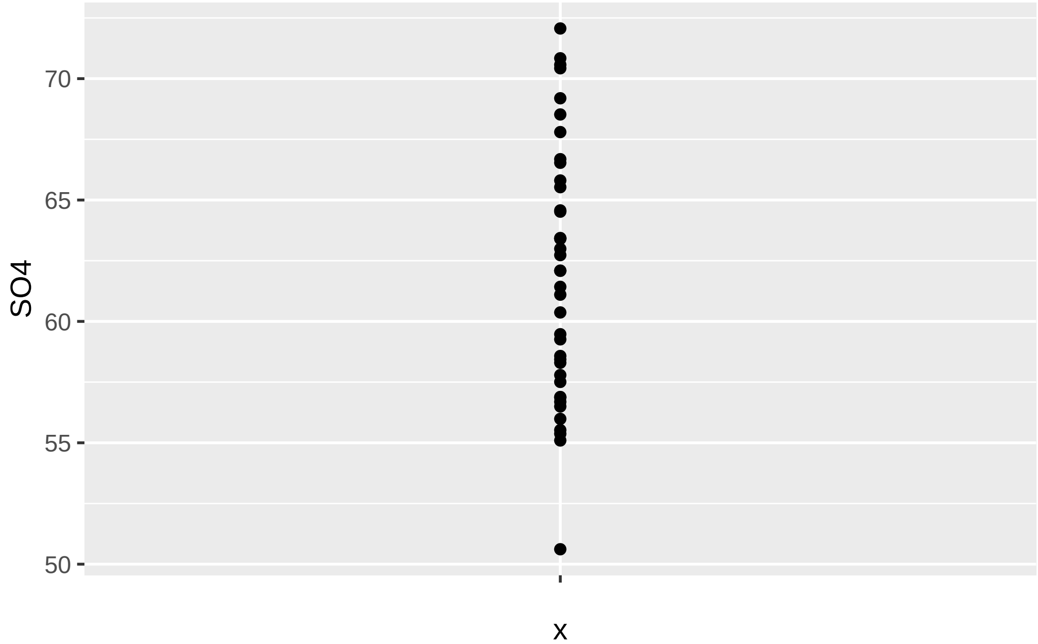
Walk through Exercise - ggplot

In this case, the package called `ggplot2` to make awesome looking plots, create 1) plot the raw data using a strip chart and 2) a jitter boxplot for the `SO4` dataset from the tutorial. For each graphical summary you have used, describe what you see and relate that to the data i.e. is it symmetrical, what are the range of values and also comment on the advantages and disadvantages of each plot for describing the `SO4` dataset?

1) Strip chart

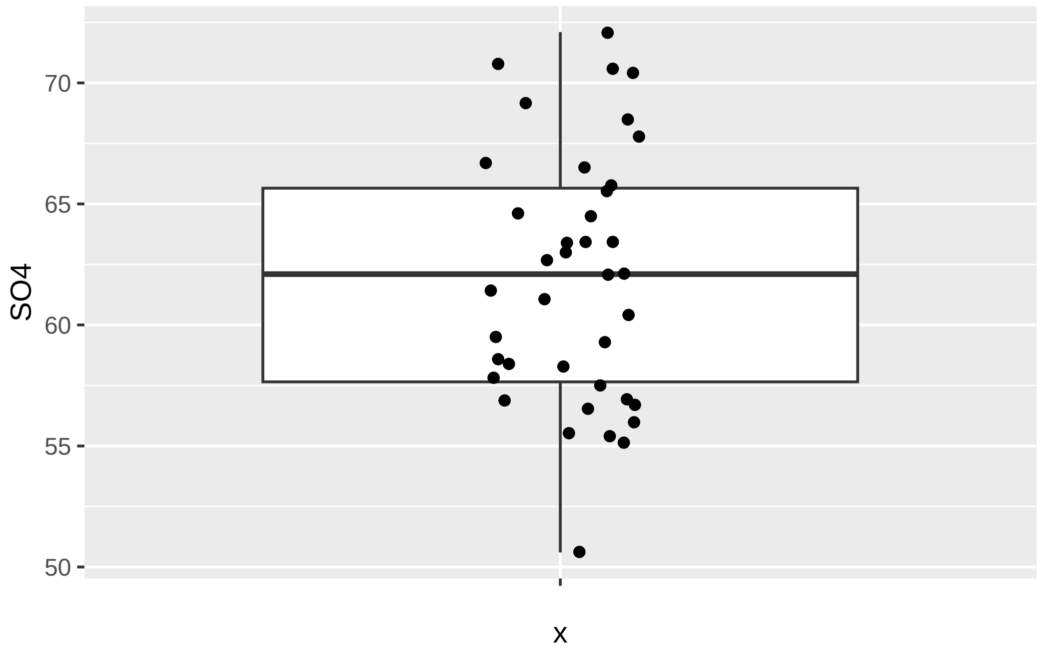
```
# install.packages(ggplot2)
library(ggplot2)
p <- ggplot(water, aes(y=SO4, x="")) +
```

```
  geom_jitter(position=position_jitter(0))
p
```



2) Boxplot with jittered points - the following is how to create a boxplot with the data points jittered

```
p <- ggplot(water, aes(y=SO4, x="")) +
  geom_boxplot() +
  geom_jitter(position=position_jitter(0.1))
p
```



Check out the cheat sheets here https://www.rstudio.com/resources/cheatsheets/ for more on making plots as well as manipulating data in R!

Walk through Exercise - skewness

In this case, the package called `moments` contains a function for calculating skew, called `skewness`. The skewness (g_1) of a dataset gives an indication of its symmetry. The sign of the skewness tells us whether the data is positively or negatively skewed. It is useful as one source of evidence for determining whether the data has a symmetrical distribution, particularly when having to assess this for many variables at once. First we must install the package using the `install.packages` function and the load it using the `library` function. Note that I have put a comment # in front as I have already installed the package and you **only need to install a package once**!

```
#install.packages("moments")
library(moments)
```

Now we can calculate the skewness of sulphate.

```
skewness(water$SO4)
```

```
[1] 0.1571807
```

Describing Soil

Given a data set, we need statistics and graphics to summarise it's key features. The statistics and graphics we use depend on the type data, i.e. numerical or categorical. The example data set we will use is from the catchment of Muttama creek which is located near Canberra. Further details about the catchment are given in Orton et al. (2016). 56 sites were sampled for soil to a depth varying between 1 and 2 m and various soil and site properties were measured.

Reference: Orton TG, Pringle MJ & Bishop, TFA (2016). A one-step approach for modelling and mapping soil properties based on profile data sampled over varying depth intervals. Geoderma 262: 174-186.

In this work we will focus on describing a subset of soil properties:

- `clay0` which is the clay (%) for the 0-30cm depth layer;
- `clay60` which is the clay (%) for the 60-90cm depth layer;
- `ec0` which is the electrical conductivity (EC) (μS/cm) for the 0-30cm depth layer;
- `ec60` which is the electrical conductivity (EC) (μS/cm) for the 60-90cm depth layer.

The clay content of a soil determines the nutrients and water it can hold, while EC is a measure of the salt in the soil which if too high limits plant growth. We wish to describe these data in terms of:

- typical values, their variability and identify unusual observations;
- differences between different depths;
- differences between the 2 soil properties; clay and EC.

We are also interested in describing the dataset in terms of the lithology and land use found at each of the sites.

The data is in the worksheet called *soil* found in the ENVX1002_Data2.xlsx file that can be found in the Tutorial and Computer lab page in Canvas. Download the file and save into your data folder in your project folder and then load the dataset into R. Remember you need to have installed and loaded the **readxl** package to do this which we did earlier

Categorical data

A common way to describe categorical data is to create a frequency table which presents the number of observations belonging to each class.

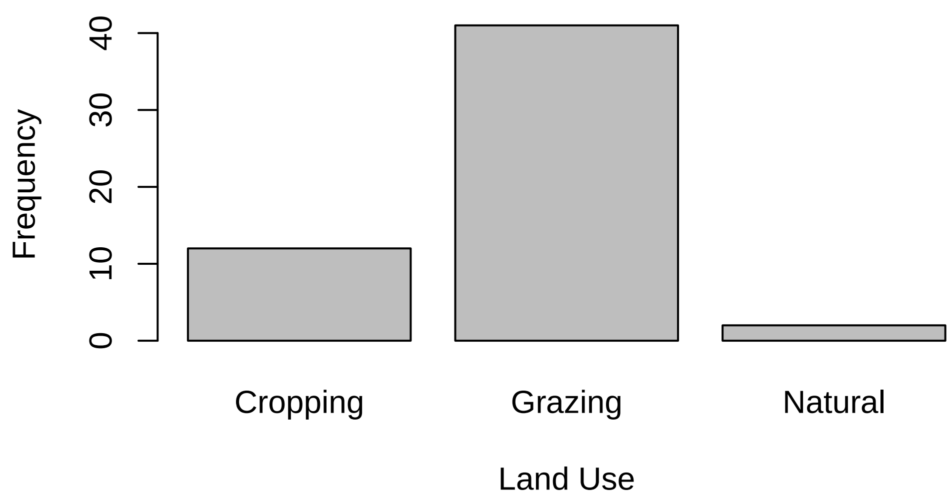
```
table(soil$land_use)
```

```
Cropping  Grazing  Natural 
      12       41        2 
```

From this we can see the dominant (most commonly sampled) land use is `Grazing`.

A common graphic used to summarise categorical data is a bar plot which can be created with the `plot` function. Note that we use the `as.factor` command to make sure r knows to do a bar plot.

```
plot(as.factor(soil$land_use),xlab="Land Use",ylab="Frequency")
```



Exercise 1

Lithology

What is the most commonly sampled lithology?

Numerical data

In this case we have 4 properties of interest, clay and EC at 2 different depths. Rather than calculating statistics on each variable separately you can in **some cases** apply the function to multiple columns in a data frame. In our case the columns of interest are the 2nd to 5th in the `soil` data frame and we can apply the `summary` function to all at once.

```
summary(soil[,2:5])
```

```
    clay0           clay60            ec0               ec60
Min.   : 4.52   Min.   :10.38   Min.   : 13.24   Min.   : 15.86
1st Qu.:16.29   1st Qu.:30.95   1st Qu.: 45.72   1st Qu.: 28.66
Median :21.78   Median :46.91   Median : 65.96   Median : 39.17
Mean   :23.20   Mean   :46.64   Mean   : 70.56   Mean   : 60.51
3rd Qu.:28.46   3rd Qu.:61.46   3rd Qu.: 88.97   3rd Qu.: 59.92
Max.   :50.24   Max.   :78.73   Max.   :176.58   Max.   :446.72
                NA's   :1                        NA's   :1
```

Exercise 2

For each of the clay and EC properties (at all depths), give the most appropriate estimate of centre and variation. Are there any unusual observations? Justify your answers.

Exercise 3

Is clay content more variable in the 0-30cm layer or in the 30-60cm layer? For the 0-30cm layer is clay or EC the most variable property. Justify your answers.

Comparing between groups.

Of interest to researchers is to assess the differences in a variable between groupings of data, e.g. weight change for different diets. In this analysis we wish to describe the difference in clay and EC between the land use or lithology classes. This will lead to more formal hypothesis testing in the later topics in ENVX1002. See https://en.wikipedia.org/wiki/Lithology for more information on Lithiology.

This is where the `tapply` function is useful. Note we can use the `$` followed by the column name to select the column as opposed to

```
tapply(soil$clay0,soil$land_use,mean)
```

```
Cropping  Grazing  Natural
24.46667 22.92976 21.08500
```

The general structure of the `tapply` function is 3 arguments which are described below based on the code above:

- the response variable on which we wish to apply the function, clay 0, `soil$clay0`;
- the categorical variable which indicates the groups we wish to separately apply the function to, land use, `soil$land_use`;
- the function we are using, `mean`.

We can use the `tapply` function for other statistics, for example the variance of each group is also important.

```
tapply(soil$clay0,soil$land_use,var)
```

```
 Cropping   Grazing   Natural
 64.56181 132.23743   0.96605
```

Using dplyr

This is a little more fancy! We can also use a package called dplyr to apply functions to different groupings of data. See https://rstudio.com/wp-content/uploads/2015/02/data-wrangling-cheatsheet.pdf for all the operations you can do. Note you will have to install the **dplyr** package first and then load it into R Studio.

```
library(dplyr)
```

```
Attaching package: 'dplyr'


The following objects are masked from 'package:stats':

    filter, lag


The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

```
soil %>%
group_by(land_use) %>%
  summarise(mean_clay0 = mean(clay0))
```

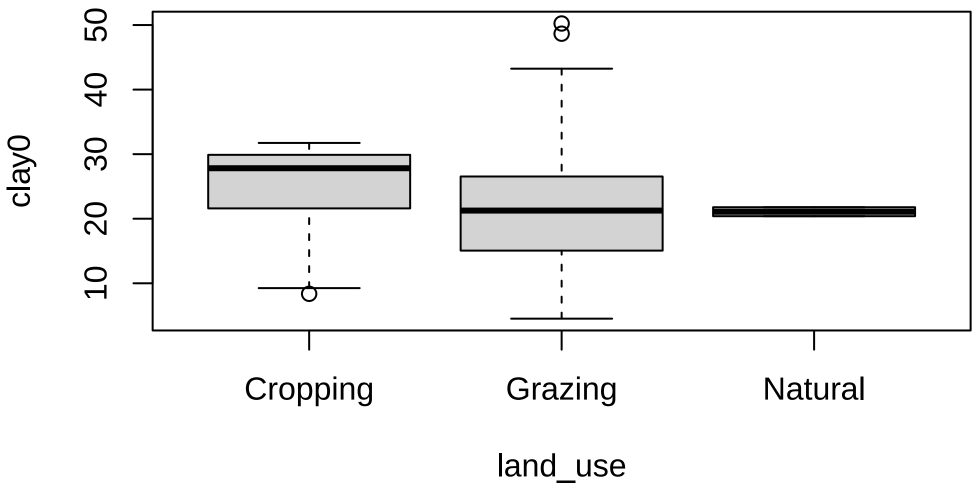
```
# A tibble: 3 x 2
  land_use mean_clay0
  <chr>         <dbl>
1 Cropping       24.5
2 Grazing        22.9
3 Natural        21.1
```

Boxplot for different groupings

We can also generate graphics for properties for different groupings. In the example below we create boxplots for each land use class. Take note of the general structure of the arguments for the `boxplot` function in this case as they used for many functions in R.

First we specify the response, `clay0`, next is the tilde, `~` which means a funcion of, then we have the predictor, `land_use`, and finally we specify the `data.frame` with the `data=` argument. Using the `data=` argument enables us to specify column names only rather than their location within the data frame, e.g. soil[,2], soil$clay0.

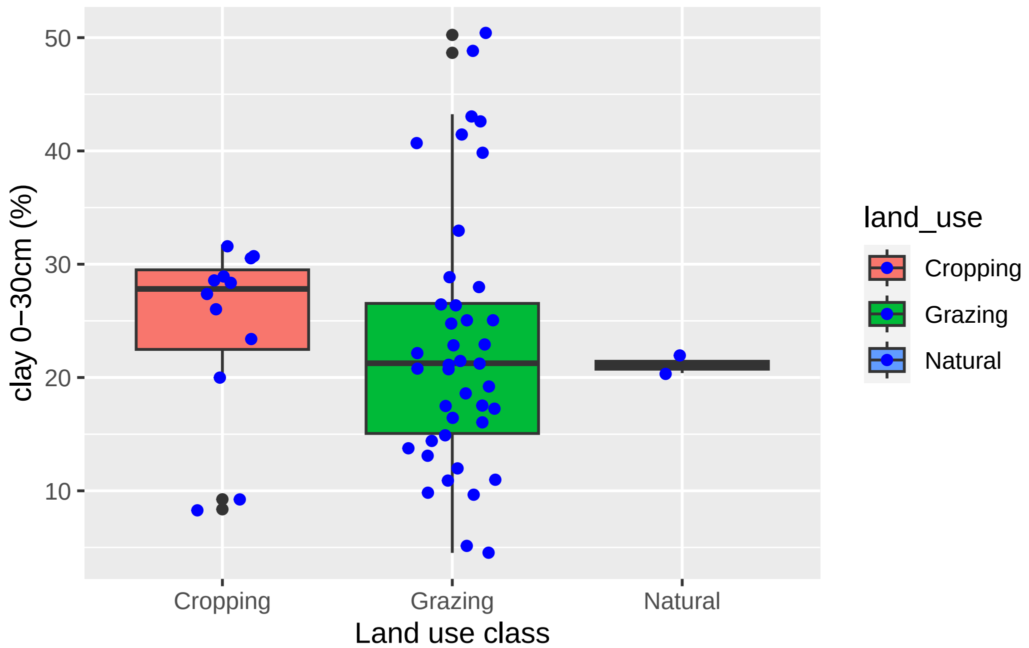
```
boxplot(clay0~land_use,data=soil)
```



We can also use a package called ggplot to create awesome looking graphs. See https://ggplot2.tidyverse.org/ for all the graphics you can do. Note you will have to install the **ggplot2** package first and then load it into R Studio.

```
library(ggplot2)
p_spoil <- ggplot(soil, aes(y = clay0, x = land_use, fill = land_use))

p_spoil +
  geom_boxplot() +
  geom_jitter(width=0.2, height = 0.2, col = "blue") +
  ylab("clay 0-30cm (%)") +
  xlab("Land use class")
```



Exercise 4

Using an appropriate measure of centre, which land use has the largest EC and clay content for each depth layer?

Exercise 5

Create boxplots of clay 0-30cm and clay 30-60cm for the different lithological classes. Are there any differences between the lithological classes based on the boxplots.

This is the end of the R component of the practical. Remember to save your files so you can access in the future.