

Using R at Grattan Institute

Will Mackey and Matt Cowgill

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Contents

Welcome	7
1 Introduction to R	9
1.1 What is R?	9
1.2 What is RStudio?	12
1.3 Installing R and RStudio	14
1.4 Packages	20
2 Why use R?	23
2.1 Why use script-based software?	23
2.2 Why use R specifically?	24
3 The tidyverse	25
3.1 What is the tidyverse and why do we use it?	25
3.2 An introduction to RMarkdown	25
4 Organising an R project at Grttan	27
4.1 Use RStudio projects, don't use <code>setwd()</code>	27
4.2 Keep your stuff together, but keep it organised	28
4.3 Grattan coding style guide	29
4.4 Resources in this package	29

5	Data Visualisation	31
5.1	Set-up and packages	31
5.2	Concepts	32
5.3	Making Grattan-y charts	35
5.4	Chart cookbook	45
5.5	Creating simple interactive graphs with <code>plotly</code>	58
5.6	bin: generate data used (before prior sections are constructed)	59
6	Reading data	61
6.1	Importing data	61
6.2	Reading common files:	62
6.3	Appropriately renaming variables	62
6.4	Getting to tidy data	62
7	Different data types	63
7.1	Tidy data	63
7.2	Dates with <code>lubridate::</code>	63
7.3	Strings with <code>stringr::</code>	63
7.4	Factors with <code>forcats::</code>	63
8	Data transformation	65
8.1	The pipe	65
8.2	Key <code>dplyr</code> functions:	65
8.3	Filter with <code>filter()</code>	65
8.4	Arrange with <code>arrange()</code>	65
8.5	Select variables with <code>select()</code>	65
8.6	Group data with <code>group_by()</code>	65
8.7	Edit and add new variables with <code>mutate()</code>	65
8.8	Summarise data with <code>summarise()</code>	65
8.9	Joining datasets with <code>*_join()</code>	65
9	Analysis	67

<i>CONTENTS</i>	5
10 Creating functions	69
10.1 It can be useful to make your own function	69
10.2 Defining simple functions	69
10.3 More complex functions	69
10.4 Sets of functions	69
10.5 Using <code>purrr::map</code>	69
10.6 Sharing your useful functions with Grattan	69
11 Version control	71
11.1 Version control is important and intimidating	71
11.2 Github	71
11.3 Git	71

Welcome

This guide is designed for everyone who uses - or would like to use - R at Grattan Institute.

It does two main things: 1. Shows you how to use R to complete common analytical tasks you'll face at Grattan. 2. Sets out some guidelines and good practices when using R at Grattan.

As a guide to using R, this website is helpful but incomplete. We can't possibly cover - or anticipate - all the skills you might need to know. If you make it to the end of this guide and want to learn more, start by reading *R for Data Science* by Hadley Wickham and Garrett Grolemund. It's free.

Any complaints or comments about this guide can be sent to Will or Matt, respectively.

This site was written in R with RMarkdown and the bookdown package.

Chapter 1

Introduction to R

Most people reading this guide will know what R is. But if you don't - that's OK!

If you have used R before and are comfortable enough with it, you might want to skip to the next page. This page is intended for people who are unfamiliar with R.

1.1 What is R?

R is a programming language that is designed by and for statisticians, data scientists, and other people who work with data. It's free - you can download R at no charge. It's also open source - you can view and (if you're game) modify the code that underlies the R language. R is available for all major computing platforms including Windows, macOS, and Linux.

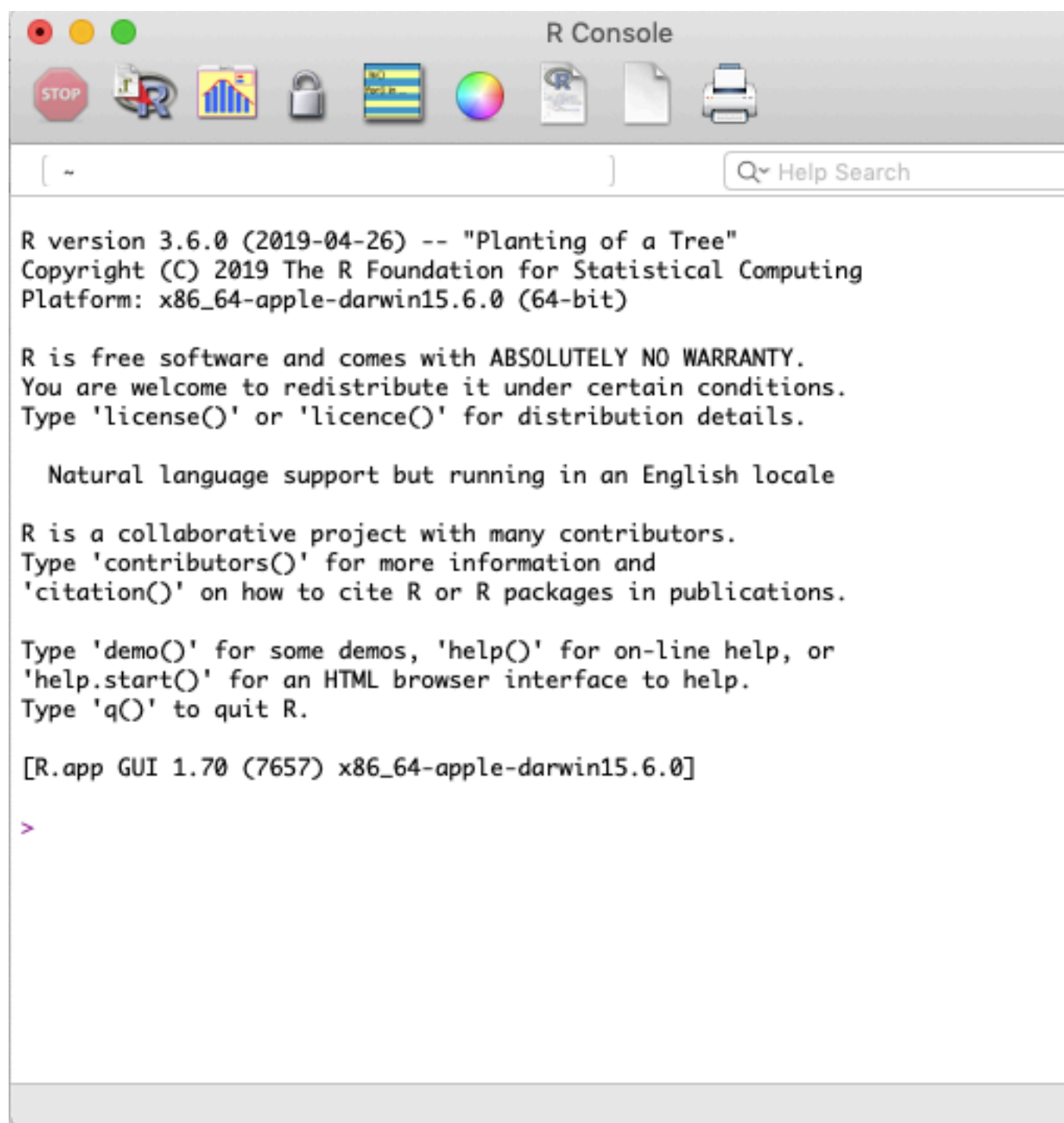
R has a lot in common with other statistical software like SAS, Stata, SPSS or Eviews. You can use those software packages to read data, manipulate it, generate summary statistics, estimate models, and so on. You can use R for all those things and more.

You interact with R by writing code. This is a little different to Stata or SPSS, which allow you to do at least part of your analyses by clicking on menus and buttons. This means the initial learning curve for R can be a little steeper than for something like SPSS, but there are great benefits to a code-based approach to data analysis (see the next page for more on this).

R also has a fair bit of overlap with general purpose programming languages like Python. But R is more focused on the sort of tasks that statisticians, data scientists, and academic researchers do.

R is quite old, having been first released publicly in 1995, but it's also growing and changing rapidly. A lot of developments in R come in the form of new add-on pieces of software - known as 'packages' - that extend R's functionality in some way. We cover packages more later in this page.

When you open R itself, you're confronted with a few disclaimers and a command prompt, similar in appearance to the Terminal on macOS or command prompt in Windows.



This might look a bit intimidating, but you'll almost never open R directly and interact with it in that way.

To analyse data with R, you will typically write out a text file containing code. This file - which we'll call a script - should be able to be read and executed by R from start to finish. The easiest way to write your code, run your script, and generate your outputs (whether that's a chart, a document, or a set of model results) is to use RStudio.

1.2 What is RStudio?

RStudio is another piece of free software you can download and run on your computer.¹ Like R itself, RStudio is available for Windows, macOS and Linux. In programmer jargon, RStudio is an “integrated development environment” or IDE. Translated to English, this means RStudio has a range of tools that help you work with R. It has a text editor for you to write R scripts, an R ‘console’ to interact directly with the language, and panes that let you see the objects you have stored in memory and any graphs you’ve created, among other things.

¹RStudio is, somewhat confusingly, a product made by a company called RStudio. Although the RStudio desktop software is free, RStudio makes money by charging for other services, like running R in the cloud. When we refer to RStudio, we’re referring to the desktop software unless we make it clear that we mean the company.

The screenshot shows the RStudio interface with the following components:

- Source Editor:** Displays an R Markdown document titled "Using_R_at_Grattan.Rmd". The text includes:


```
'packages' - that extend R's functionality in some way. We cover packages more [later in this page](#packages).
16
17 When you open R itself, you're confronted with a few disclaimers and a command prompt, similar in appearance to the Terminal on macOS or command prompt in Windows.
18
19 `r knitr::include_graphics("atlas/r_screenshot.png")`
20
21 This looks a bit intimidating, but you'll almost never open R directly and interact with it in that way.
22
23 To analyse data with R, you will typically write out a text file containing your code. This file - which we'll call a script - should be able to be read and executed by R from start to finish. The easiest way to write your code, run your script, and generate your outputs (whether that's a chart, a document, or a set of model results) is to use RStudio.
24
25 ## What is RStudio?
26
27 RStudio is another piece of free software you can download and run on your computer.^[RStudio is, somewhat confusingly, a product made by a company called RStudio. Although the RStudio desktop software is free, RStudio makes money by charging for other services, like running R in the cloud.] It's also available for Windows, macOS and Linux. In programmer jargon, RStudio is an "integrated development environment" or IDE. This means RStudio has a range of tools that help you work with R. It has a text editor for you to write R scripts, an R 'console' to interact directly with the language, and panes that let you see the objects you have stored in memory and any graphs you've created.
28
29
30
31 You'll almost always interact with R by opening RStudio. You need to install R se
32
33 ## Installing R and RStudio
34
35 ## Packages {#packages}
36
37 ### What is a package?
38
```
- Console:** Shows the output of the command `library(tidyverse)`. It lists attached packages and their versions:

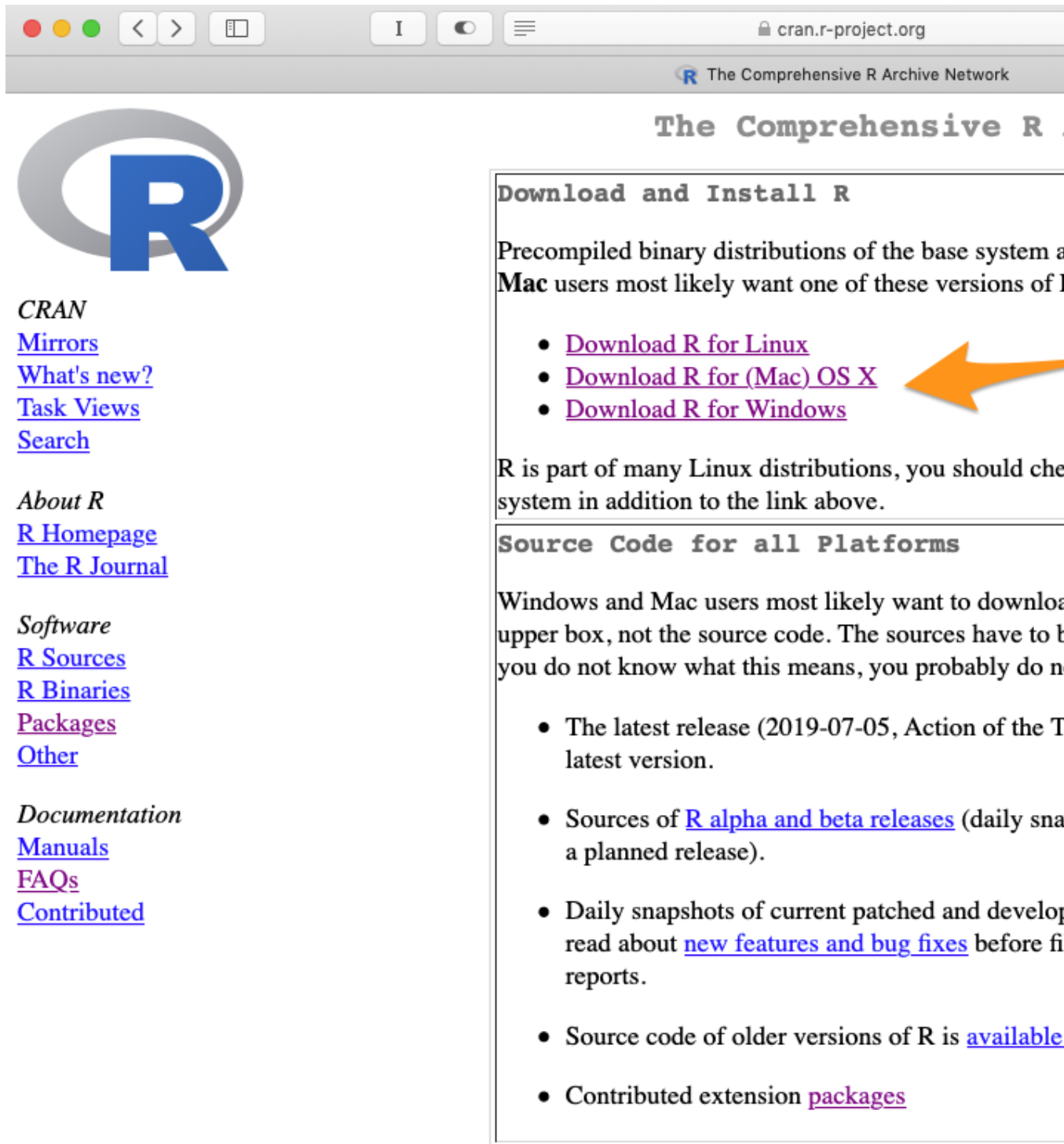

```
> library(tidyverse)
— Attaching packages — tidyverse 1.2.1.9000
✓ ggplot2 3.2.1    ✓ purrr  0.3.2
✓ tibble  2.1.3    ✓ dplyr  0.8.3
✓ tidyr   0.8.3    ✓ stringr 1.4.0
✓ readr   1.3.1    ✓ forcats 0.4.0
— Conflicts — tidyverse_conflicts()
✖ dplyr::filter() masks stats::filter()
✖ dplyr::lag()    masks stats::lag()
> ggplot(mtcars, aes(x = wt, y = mpg)) + geom_point() + grattantheme::theme_grattan()
>
```
- Annotations:**
 - Orange text in the Source Editor: "This is where a text editor where you can write an R script - or an RMarkdown document like this one!"
 - Orange text in the Console: "This is your 'console', where you can directly give commands to R and see the results"

You'll almost always interact with R by opening RStudio.

1.3 Installing R and RStudio

Although you'll usually work with R by opening RStudio, you need to install both R and RStudio separately.

Install R by going to CRAN, the Comprehensive R Archive Network. CRAN is a community-run website that houses R itself as well as a broad range of R packages.




The screenshot shows a web browser window with the address bar displaying `cran.r-project.org`. The page title is "The Comprehensive R Archive Network". The main heading is "The Comprehensive R". Below this, there is a large blue "R" logo. To the left of the logo, there is a sidebar with links: "CRAN", "Mirrors", "What's new?", "Task Views", "Search", "About R", "R Homepage", "The R Journal", "Software", "R Sources", "R Binaries", "Packages", "Other", "Documentation", "Manuals", "FAQs", and "Contributed". To the right of the logo, there is a section titled "Download and Install R". This section contains a paragraph: "Precompiled binary distributions of the base system are available for Linux, Mac OS X, and Windows. Mac users most likely want one of these versions of R". Below this paragraph, there is a list of links: "Download R for Linux", "Download R for (Mac) OS X", and "Download R for Windows". An orange arrow points to the "Download R for (Mac) OS X" link. Below the list, there is a paragraph: "R is part of many Linux distributions, you should check your distribution's documentation for more information on installing R in addition to the link above." Below this paragraph, there is a section titled "Source Code for all Platforms". This section contains a paragraph: "Windows and Mac users most likely want to download the precompiled binaries in the upper box, not the source code. The sources have to be compiled. If you do not know what this means, you probably do not want to use the source code." Below this paragraph, there is a list of links: "The latest release (2019-07-05, Action of the Task Force on R's latest version)", "Sources of R alpha and beta releases (daily snapshots of R in development, a planned release)", "Daily snapshots of current patched and development versions of R. Read about new features and bug fixes before filing reports.", "Source code of older versions of R is available", and "Contributed extension packages".

cran.r-project.org

The Comprehensive R Archive Network

The Comprehensive R



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Software

- [R Sources](#)
- [R Binaries](#)
- [Packages](#)
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- [Contributed](#)

Download and Install R

Precompiled binary distributions of the base system are available for Linux, Mac OS X, and Windows. Mac users most likely want one of these versions of R

- [Download R for Linux](#)
- [Download R for \(Mac\) OS X](#)
- [Download R for Windows](#)

R is part of many Linux distributions, you should check your distribution's documentation for more information on installing R in addition to the link above.

Source Code for all Platforms

Windows and Mac users most likely want to download the precompiled binaries in the upper box, not the source code. The sources have to be compiled. If you do not know what this means, you probably do not want to use the source code.

- The latest release (2019-07-05, Action of the Task Force on R's latest version).
- Sources of [R alpha and beta releases](#) (daily snapshots of R in development, a planned release).
- Daily snapshots of current patched and development versions of R. Read about [new features and bug fixes](#) before filing reports.
- Source code of older versions of R is [available](#)
- Contributed extension [packages](#)

You want to download the latest base R release, as a ‘binary’. Don’t worry, you don’t need to know what a binary is.

For macOS, the page will look like this:



CRAN

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R for M

This directory contains binaries for a base distribution and packages. Mac OS 8.6 to 9.2 (and Mac OS X 10.1) are no longer supported. For old Mac OS X systems (which is R 1.7.1) [here](#). Releases for old Mac OS X are found in the [old](#) directory.

Note: CRAN does not have Mac OS X systems and cannot compile binaries. When assembling binaries, please use the normal precautions.

As of 2016/03/01 package binaries for R versions older than 3.0.0 should adjust the CRAN mirror setting accordingly.

R 3.6.1 "Action of the To

Important: since R 3.4.0 release we are now providing binary packages. This toolkit to provide support for OpenMP and C++17 standard library. Read the tools from the [tools](#) directory and read the corresponding notes.

Please check the MD5 checksum during the mirroring process. For example type `md5 R-3.6.1.pkg` in the *Terminal* application to print the MD5 checksum for the package. You can also validate the signature using `pkgutil --check-signature R-3.6.1.pkg`.

Click here

Latest

[R-3.6.1.pkg](#)

MD5-hash: 279e6662103dfe6a625b4573143cb995

SHA1-

hash: 4e932f8e5013870d2a9179b54eae277f41657b0

(ca. 76MB)

R 3.6.1 binary for OS X

Contains R 3.6.1 frame

Tcl/Tk 8.6.6 X11 library

are optional and can be

are only needed if you v

package documentation

For Windows, you'll need to click on the 'base' version, and then click again to start the download.



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Subdirectories:

[base](#)

[contrib](#)

[old contrib](#)

[Rtools](#)

**click
here...**

Binaries for base distrib

Binaries of contributed C

There is also informatio

and corresponding envin

Binaries of contributed C

managed by Uwe Ligge

Tools to build R and R p

Windows, or to build R

Please do not submit binaries to CRAN. Pack
questions / suggestions related to Windows bi

You may also want to read the [R FAQ](#) and [R t](#)

Note: CRAN does some checks on these bina
downloaded executables.



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[Download R 3.6.1 for](#)

[Installation and other inst](#)

[New features in this versi](#)

If you want to double-check t
compare the [md5sum](#) of the .
both [graphical](#) and [command](#)

Once you've installed R, you'll need to install RStudio. Go to the RStudio website and install the latest version of RStudio Desktop (open source license).

Once they're both installed, get started by opening RStudio.

1.4 Packages

R comes with a lot of functions - commands - built in to do a broad range of tasks. You could, if you really wanted, import a dataset, clean it up, estimate a model, and make a plot all using the functions that come with R - known as 'base R'².

But a lot of our work at Grattan uses add-on software to base R, known as 'packages'. Some packages, like the popular 'dplyr', make it quicker and/or easier to do tasks that you could otherwise do in base R. Other packages expand the possibilities of what R can do - like fitting a machine learning model, for example.

Like R itself, packages are free and open source. You can install them from within RStudio.

²Technically some of the 'built-in' functions are part of packages, like the `tools`, `utils` and `stats` packages that come with R. We'll refer to all these as base R.

At Grattan, we make heavy use of a set of related packages known collectively as the **tidyverse**. We'll cover this more in a later chapter.

1.4.1 Installing packages

You'll typically install packages using the console in RStudio. That's the part of the window that, by default, sits in the bottom-left corner of the screen.

In our work at Grattan, we use packages from two different source: CRAN and Github. The main difference you need to know about is that we use different commands to install packages from these two sources.

To install a package from CRAN, we use the command `install.packages()`.

For example, this code will install the `ggplot2` package from CRAN:

```
install.packages("ggplot2")
```

The easiest way to install a package from Github is to use the function `install_github()`. Unfortunately, this function doesn't come with base R. The `install_github()` function is part of the **remotes** package. To use it, we first need to install **remotes** from CRAN:

```
install.packages("remotes")
```

Now we can install packages from Github using the `install_github()` function from the **remotes** package. For example, here's how we would install the Grattan `ggplot2` theme, which we'll discuss later in this website:

```
remotes::install_github("mattcowgill/grattantheme", dependencies = TRUE, upgrade = "always")
```

1.4.2 Using packages

Before using a function that comes from a package, as opposed to base R, you need to tell R where to look for the function. There are two main ways to do that.

We can either load (aka 'attach') the package by using the `library()` function. We typically do this at the top of a script.

```
library(remotes)
```

```
# Now that the `remotes` package is loaded, we can use its `install_github()` function:
```

```
install_github("mattcowgill/grattantheme")
```

Or, we can use two colons - `::` - to tell R to use an individual function from a package without loading it:

```
remotes::install_github("mattcowgill/grattantheme")
```

It usually makes sense to load a package with `library()`, unless you only need to use one of its function once or twice. There's no harm to using the `::` operator even if you have already loaded a package with `library()`. This can remove ambiguity both for R and for humans reading your code, particularly if you're using an obscure function - it makes it clearer where the function comes from.

Chapter 2

Why use R?

We can break this question into two parts:

1. Why use script-based software to analyse data?
2. Why use R, specifically?

2.1 Why use script-based software?

It's important for our analyses to be **reproducible**. This means that all of the steps that were taken to go from your raw data to your final outputs are clearly set out and can be reproduced if necessary.

Reproducibility is very important for QC, particularly of complex analyses - if it's not clear what you've done, it's hard for someone to check your work. It also makes things easier for you in the future - coming back to an old analysis a few months or years down the track is much easier if it's reproducible.

Script-based analyses are more likely to be reproducible.¹ A script sets out all the steps that were taken from reading in data, to tidying it, to estimating models or summary statistics and generating output.

Analysis that isn't script based, like work done in Excel, is not reproducible. It is never clear what steps were taken, in which order, to go from the raw data to the output. It isn't even always clear in a spreadsheet what is the 'raw data' and what has been modified in some way.

Using scripts makes us less susceptible to the sort of errors famously made by the economists Reinhart and Rogoff in their Excel-based analysis of the effect

¹Using a script-based approach doesn't guarantee that your analysis will be truly reproducible. If your work involves some steps that aren't documented in the script - such as data "cleaning" in Excel - then it is not fully reproducible.

of public debt on economic growth. It's still possible to make errors in a script-based analysis, but those errors are easier to find when the analysis is more transparent.

Script-based analysis software also allows us to: * Work with larger data sets; * Work with data in a broader range of formats; * Easily combine different data sets; * Automate tasks and build from previous analyses; and * Estimate statistical models.

2.2 Why use R specifically?

Doing reproducible, script-based, research doesn't necessarily involve using R. It's perfectly possible to do reproducible work in Stata or Python (though harder in SPSS, where data is primarily manipulated by clicking things).

We use R specifically because: * It's free! * It's open source. * It's powerful. * It's flexible. * It has an active community extending its capabilities all the time and providing support online. * It is becoming the norm in academic research and common in the corporate world.

Everything you can do in Excel can be done in R.

Chapter 3

The tidyverse

3.1 What is the tidyverse and why do we use it?

3.2 An introduction to RMarkdown

Chapter 4

Organising an R project at Grttan

By sticking to a consistent way of organising our analyses, we're more able to read and check each others' work. This is really important! If your analysis is messy, you're more likely to make errors, and less likely to spot them. Other people will find it hard to check your analysis and you'll find it harder to return to it down the track. All our work, in R or otherwise, should heed the "hit by a bus" rule - if you're not around, colleagues should be able to access, understand, verify, and build on the work you've done.

This page sets out some guidelines for organising your work in R at Grattan. It covers:

- Using RStudio projects and relative filepaths
- Using a consistent subfolder structure
- Naming your scripts and keeping them manageable
- Coding style at Grattan

4.1 Use RStudio projects, don't use `setwd()`

You'll almost always be reading and/or writing files to disk as part of your analysis in R. To do this, R needs to know where to read files from and save files to - your working directory.

One way to tell R which folder to use as your working directory is using the command `setwd()`, like `setwd("~/Desktop/some random folder")` or `setwd("C:\\Users\\mcowgill\\Documents\\Somerandomfolder")`. This is a bad idea! If anyone - including you - tries to run your scripts on a different machine,

with a different folder structure, it probably won't work. If people can't get past the first line when they're trying to run your script, they can't check your work.

Creating a 'project' in RStudio is a way to set your working directory in a way that's portable across machines. Creating an RStudio project is straightforward: **click File, then New Project**. You can then choose to start your project in a new directory, or an existing directory. Simple!

RStudio will then create a file with an .Rproj extension in the folder you've chosen. When you want to work in this project, just open the .Rproj file, or click File -> Open project in RStudio. Your working directory will be set to the directory that contains the .Rproj file.

4.2 Keep your stuff together, but keep it organised

Your script(s), data, and output should generally all live in the same place.¹ That place should be the folder that contains the .Rproj file that was created when you created an RStudio project.

4.2.1 Filepaths

Filepaths should be relative to the working directory, and the working directory should be set by the project.

Good

```
hes <- read_csv("data/HES/hes1516.csv")
grattan_save("images/expenditure_by_income.pdf")
```

Bad

```
hes <- read_csv("/Users/mcowgill/Desktop/hes1516.csv")
hes <- read_csv("C:\\Users\\mcowgill\\Desktop\\hes1516.csv")
grattan_save("/Users/mcowgill/Desktop/images/expenditure_by_income.pdf")
```

¹This isn't always possible, like when you're working with restricted-access microdata. But unless there's a really good reason why you can't keep your data together with the rest of your work, you should do it.

4.2.2 Keep your scripts manageable

As a general rule of thumb, use one script per output. It should be clear what your script is trying to do (use comments!).

Consider breaking your analysis into pieces. For example:

- 01_import.R
- 02_tidy.R
- 03_model.R
- 04_visualise.R

Don't include interactive work (like `View(mydf)`, `str(mydf)`, `mean(mydf$variable)`, etc.) in your saved script.

4.2.3 Use subfolders of your project folder

Remember the hit-by-a-bus rule. It should be easy for any Grattan colleague to open your project folder and get up to speed with what it does. Putting all your files - raw data, scripts, output - in the one folder makes it harder to understand how your work fits together.

Use subfolders to clearly separate your code, raw data, and output.

4.3 Grattan coding style guide

Short summary of why

[Link to style guide](#)

4.4 Resources in this package

- Starting a piece of analysis 'cheat sheet'.
- Updated style guide.
- Written guide/slides.

Chapter 5

Data Visualisation

[intro]

5.1 Set-up and packages

This section uses the package `ggplot2` to visualise data, and `dplyr` functions to manipulate data. Both of these packages are loaded with `tidyverse`. The `scales` package helps with labelling your axes.

The `grattantheme` package is used to make charts look Grattan-y. The `absmapsdata` package is used to help make maps.

```
library(tidyverse)
library(grattantheme)
library(absmapsdata)
library(sf)
library(scales)
```

For most charts in this chapter, we'll use the `population_table` data summarised here. It contains the population in each state between 2013 and 2018:

```
population_table <- read_csv("data/population_sa4.csv") %>%
  filter(data_item == "Persons - Total (no.)") %>%
  mutate(pop = as.numeric(value),
         year = as.factor(year)) %>%
  group_by(year, state) %>%
  summarise(pop = sum(pop))
```

```
# Show the first six rows of the new dataset
head(population_table)
```

```
## # A tibble: 6 x 3
## # Groups:   year [1]
##   year state                pop
##   <fct> <chr>                <dbl>
## 1 2013 Australian Capital Territory 383257
## 2 2013 New South Wales             7404032
## 3 2013 Northern Territory         241722
## 4 2013 Other Territories           2962
## 5 2013 Queensland                 4652824
## 6 2013 South Australia            1671488
```

5.2 Concepts

The `ggplot2` package is based on the grammar of graphics. ...

The main ingredients to a `ggplot` chart:

- **Data:** what data should be plotted. e.g. `data`
- **Aesthetics:** what variables should be linked to what chart elements. e.g. `aes(x = population, y = age)` to connect the `population` variable to the x axis, and the `age` variable to the y axis.
- **Geoms:** how the data should be plotted. e.g. `geom_point()` will produce a scatter plot, `geom_col` will produce a column chart.

Each plot you make will be made up of these three elements. The full list of standard geoms is listed in the `tidyverse` documentation.

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION> (
    mapping = aes(<MAPPINGS>),
    stat = <STAT>,
    position = <POSITION>
  ) +
  <COORDINATE_FUNCTION> +
  <FACET_FUNCTION>
```

For example, you can plot a column chart by passing the `population_table` dataset into `ggplot()` (“make a chart with this data”). This produces an empty plot:

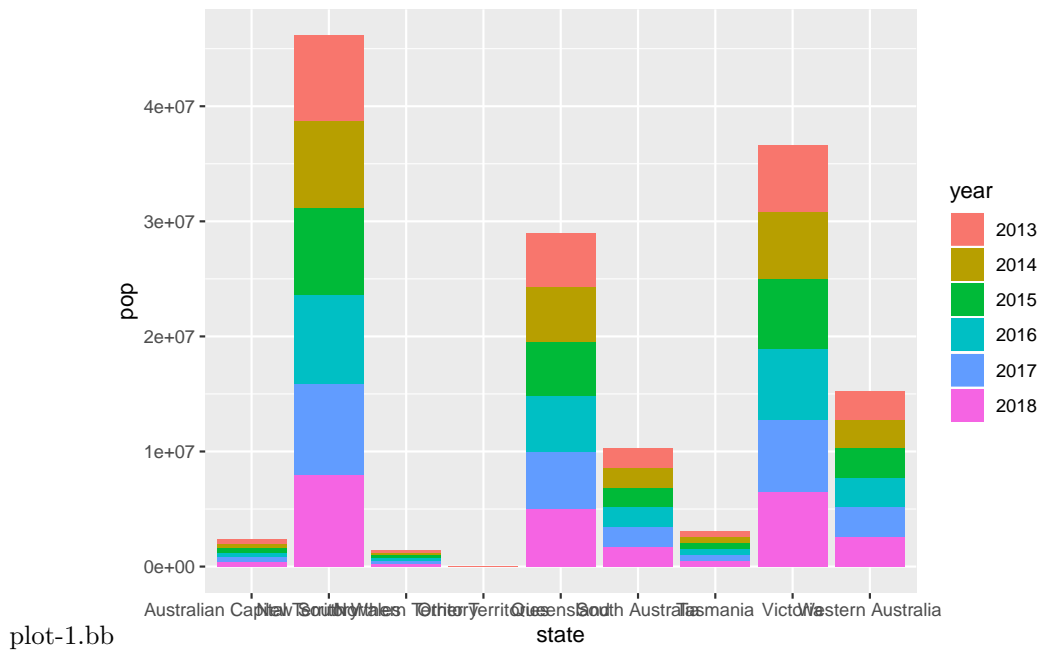

```
population_table %>%  
  ggplot()
```

plot-1.bb

Next, set the `aes` (aesthetics) to `x = state` (“make the x-axis represent state”), `y = pop` (“the y-axis should represent population”), and `fill = year` (“the fill colour represents year”). Now `ggplot` knows where things should go: {r empty with aes} `population_table %>% ggplot(aes(x = state, y = pop, fill = year))`

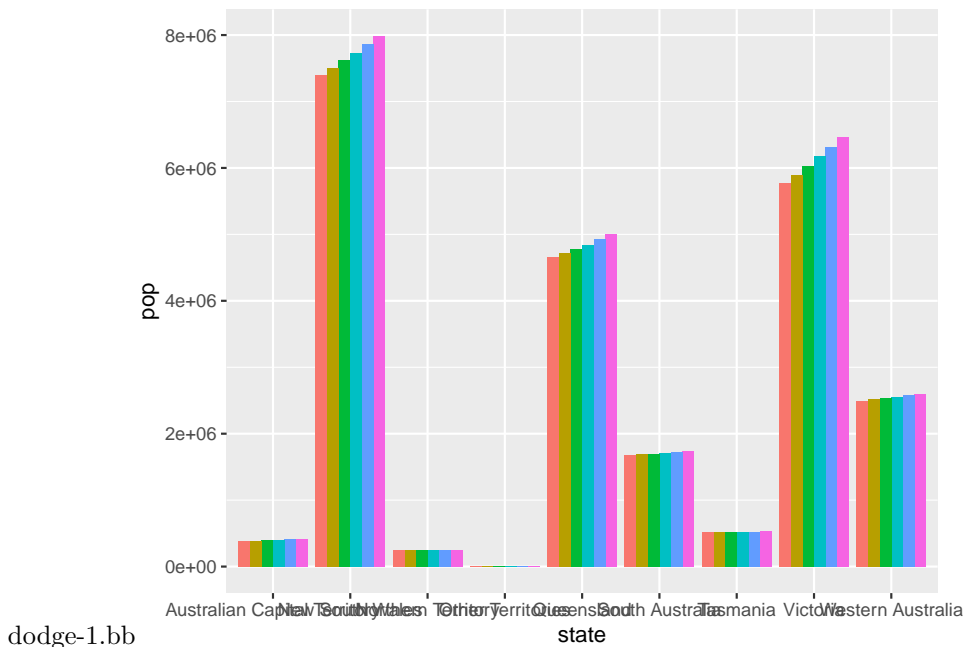
Now that `ggplot` knows where things should go, it needs to *how* to plot them. For this we use `geoms`. Tell it to plot a column chart by using `geom_col`:

```
population_table %>%  
  ggplot(aes(x = state,  
            y = pop,  
            fill = year)) +  
  geom_col()
```



Great! Although stacking populations is a bit silly. You can adjust the way **geoms** work with arguments. In this case, tell it to place the different categories next to each other rather than ontop of each other using **position = "dodge"**:

```
population_table %>%
  ggplot(aes(x = state,
             y = pop,
             fill = year)) +
  geom_col(position = "dodge")
```



That's nicer. The following sections in this chapter will build on this chart. The rest of the chapter will explore:

- Grattanising your charts and choosing colours
- Saving charts according to Grattan templates
- Making bar, line, scatter and distribution plots
- Making maps and interactive charts
- Adding chart labels

5.3 Making Grattan-y charts

The `grattantheme` package contains functions that help *Grattanise* your charts. It is hosted here: <https://github.com/mattcowgill/grattantheme>

You can install it with `devtools::install_github` from the package:

```
install.packages("devtools")
remotes::install_github("mattcowgill/grattantheme")
```

The key functions of `grattantheme` are:

- `theme_grattan`: set size, font and colour defaults that adhere to the Grattan style guide.

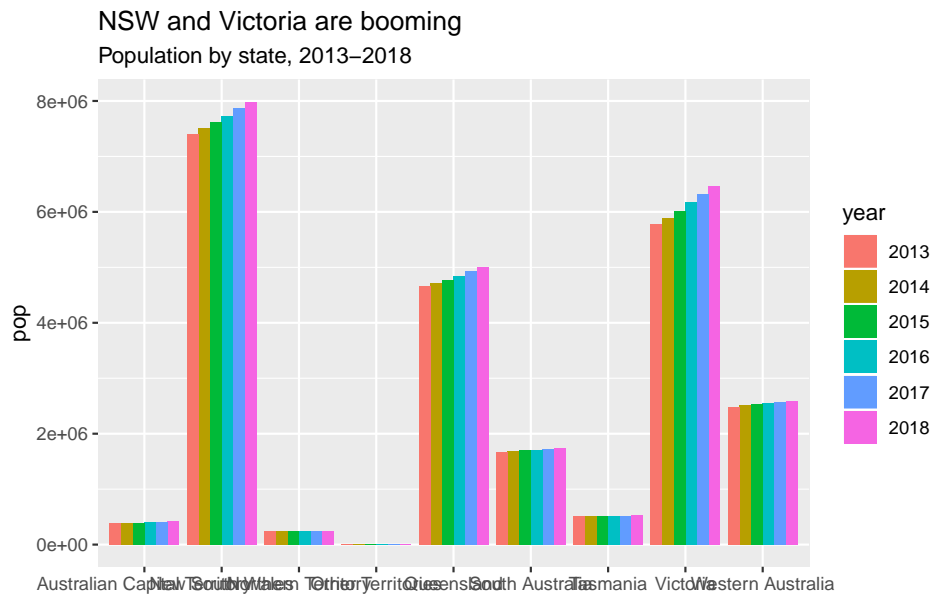
- `grattan_y_continuous`: sets the right defaults for a continuous y-axis.
- `grattan_colour_continuous`: pulls colours from the Grattan colour palette for colour aesthetics.
- `grattan_fill_continuous`: pulls colours from the Grattan colour palette for fill aesthetics.
- `grattan_save`: a save function that exports charts in correct report or presentation dimensions.

This section will run through some examples of *Grattanising* charts. The `ggplot` functions are explored in more detail in the next section.

5.3.1 Making Grattan charts

Start with a column chart, similar to the one made above:

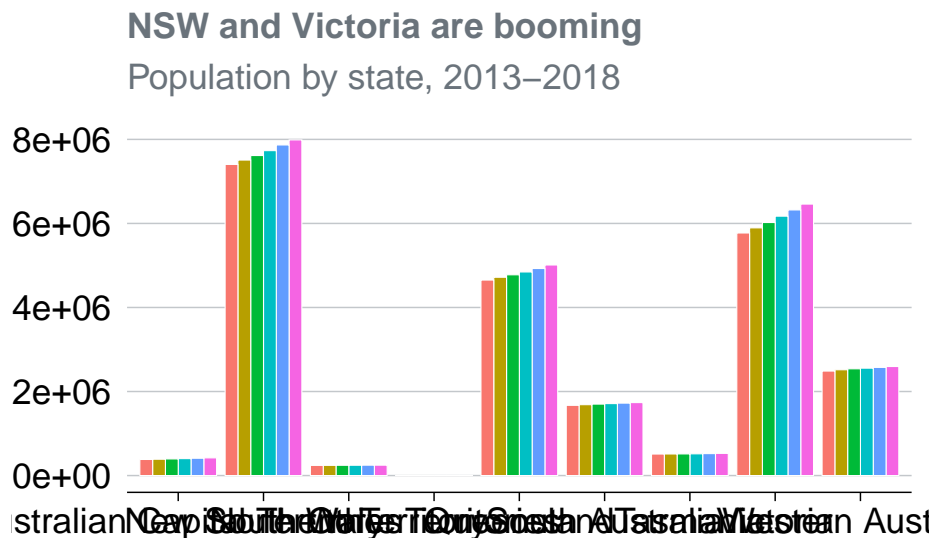
```
base_chart <- population_table %>%  
  ggplot(aes(x = state,  
             y = pop,  
             fill = year)) +  
  geom_col(position = "dodge") +  
  labs(x = "",  
       title = "NSW and Victoria are booming",  
       subtitle = "Population by state, 2013-2018",  
       caption = "Source: ABS Regional Dataset (2019)")  
  
base_chart
```



Source: ABS Regional Dataset (2019)

Let's make it Grattany. First, add `theme_grattan` to your plot:

```
base_chart +  
  theme_grattan()
```



Source: ABS Regional Dataset (2019)

Then `grattan_y_continuous` to align the x-axis with zero. This function takes the same arguments as `scale_y_continuous`, so you can add `labels = comma()` to reformat the y-axis labels:

```
base_chart +
  theme_grattan() +
  grattan_y_continuous(labels = comma)
```



Source: ABS Regional Dataset (2019)

To define fill colours, use `grattan_fill_manual` with the number of colours you need (six, in this case):

```
pop_chart <- base_chart +
  theme_grattan() +
  grattan_y_continuous(labels = comma) +
  grattan_fill_manual(6)

pop_chart
```



Source: ABS Regional Dataset (2019)

Nice chart! Now you can save it and share it with the world.

5.3.2 Saving Grattan charts

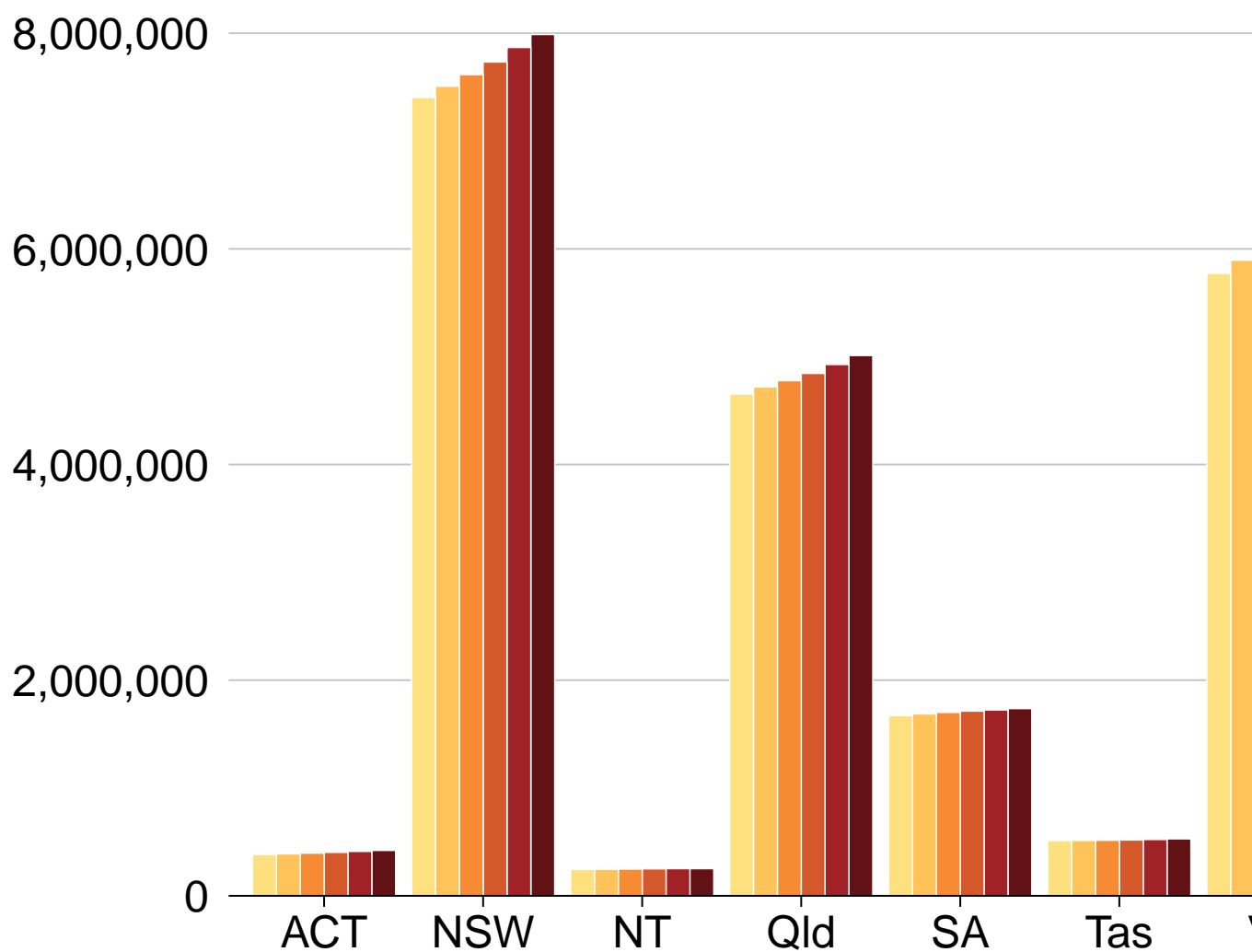
The `grattan_save` function saves your charts according to Grattan templates. It takes these arguments:

- **filename:** the path, name and file-type of your saved chart. eg: "atlas/population_chart.pdf".
- **object:** the R object that you want to save. eg: `pop_chart`. If left blank, it grabs the last chart that was displayed.
- **type:** the Grattan template to be used. This is one of:
 - "normal" The default. Use for normal Grattan report charts, or to paste into a 4:3 Powerpoint slide. Width: 22.2cm, height: 14.5cm.
 - "normal_169" Only useful for pasting into a 16:9 format Grattan Powerpoint slide. Width: 30cm, height: 14.5cm.
 - "tiny" Fills the width of a column in a Grattan report, but is shorter than usual. Width: 22.2cm, height: 11.1cm.
 - "wholecolumn" Takes up a whole column in a Grattan report. Width: 22.2cm, height: 22.2cm.
 - "fullpage" Fills a whole page of a Grattan report. Width: 44.3cm, height: 22.2cm.
 - "fullslide" Creates an image that looks like a 4:3 Grattan Powerpoint slide, complete with logo. Width: 25.4cm, height: 19.0cm.

- "fullslide_169" Creates an image that looks like a 16:9 Grattan Powerpoint slide, complete with logo. Use this to drop into standard presentations. Width: 33.9cm, height: 19.0cm
 - "blog" Creates a 4:3 image that looks like a Grattan Powerpoint slide, but with less border whitespace than "fullslide".
 - "fullslide_44" Creates an image that looks like a 4:4 Grattan Powerpoint slide. This may be useful for taller charts for the Grattan blog; not useful for any other purpose. Width: 25.4cm, height: 25.4cm.
 - Set `type = "all"` to save your chart in all available sizes.
-
- `height`: override the height set by `type`. This can be useful for really long charts in blogposts.
 - `save_data`: exports a `csv` file containing the data used in the chart.
 - `force_labs`: override the removal of labels for a particular `type`. eg `force_labs = TRUE` will keep the y-axis label.

To save the `pop_chart` plot created above as a whole-column chart for a **report**:

```
grattan_save("atlas/population_chart_report.pdf", pop_chart, type = "wholecolumn")
```

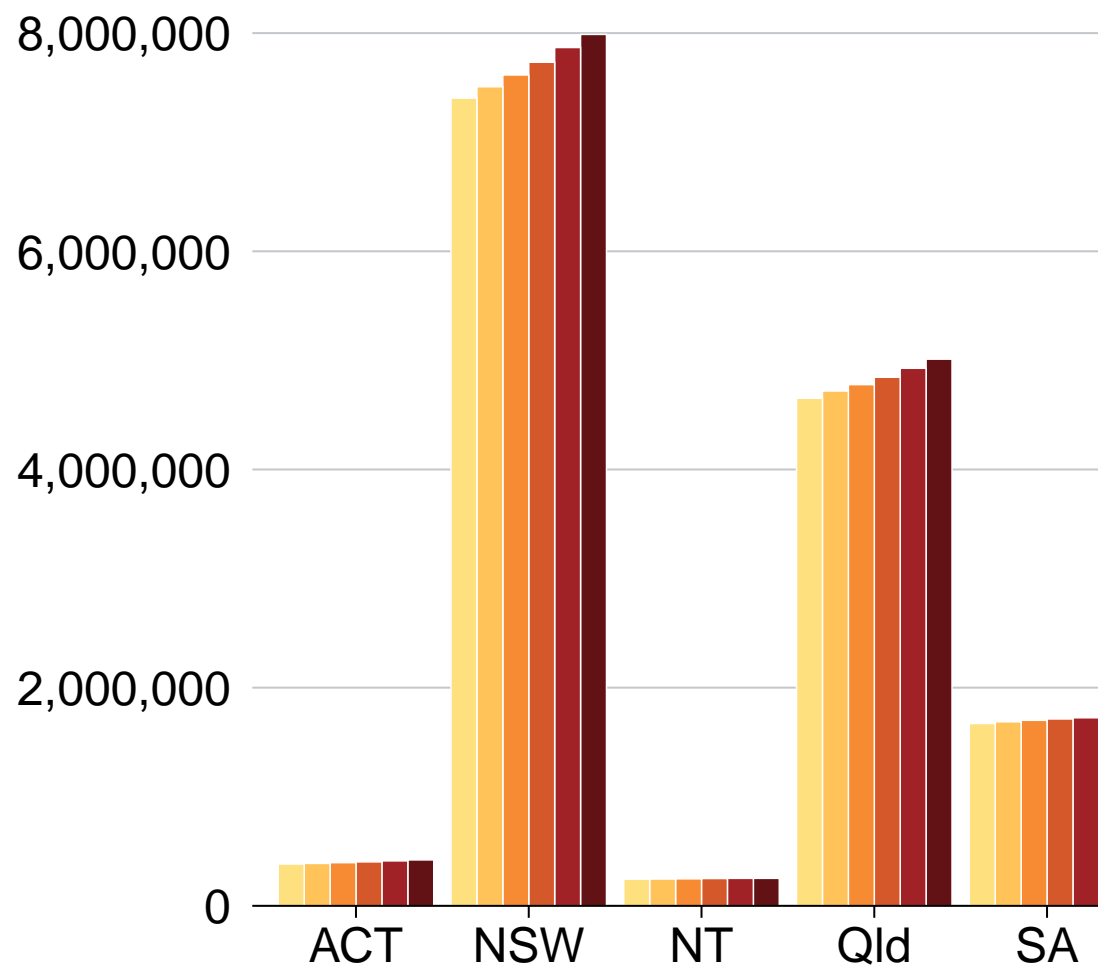



To save it as a **presentation** slide instead, use `type = "fullslide"`:

```
grattan_save("atlas/population_chart_presentation.pdf", pop_chart, type = "fullslide")
```

NSW and Victoria are booming

Population by state, 2013–2018



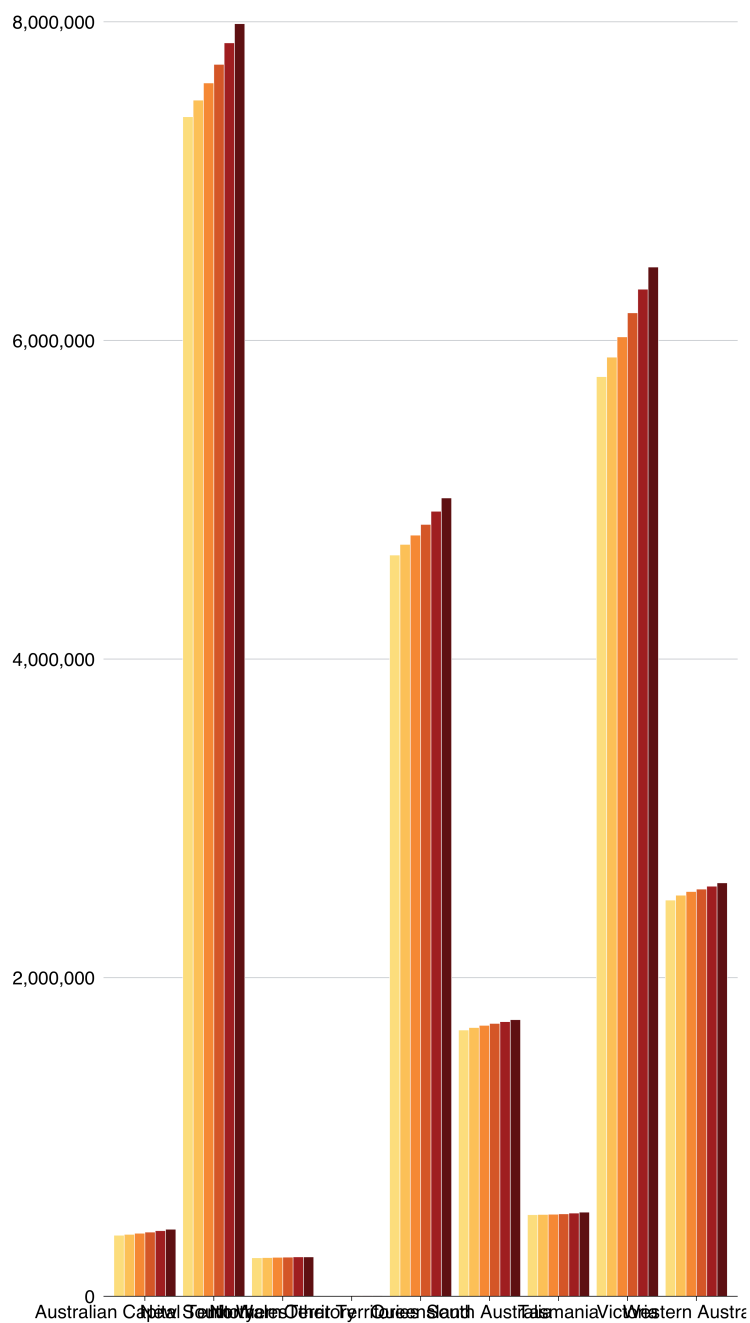
Source: ABS Regional Dataset (2019)

Or, if you want to emphasise the point in a *really tall* chart for a **blogpost**, you can use `type = "blog"` and adjust the `height` to be 50cm. Also note that because this is for the blog, you should save it as a `png` file:

```
grattan_save("atlas/population_chart_blog.png", pop_chart,  
             type = "blog", height = 50)
```

NSW and Victoria are boomingGRATTAN
Institute

Population by state, 2013-2018



Source: ABS Regional Dataset (2019)

And that's it! The following sections will go into more detail about different chart types in R, but you'll mostly use the same basic `grattantheme` formatting you've used here.

5.4 Chart cookbook

This section takes you through a few often-used chart types.

5.4.1 Bar charts

Bar charts are made with `geom_bar` or `geom_col`. Creating a bar chart will look something like this:

```
ggplot(data = <data>) +  
  geom_bar(aes(x = <xvar>, y = <yvar>),  
    stat = <STAT>,  
    position = <POSITION>  
  )
```

It has two key arguments: `stat` and `position`.

First, `stat` defines what kind of *operation* the function will do on the dataset before plotting. Some options are:

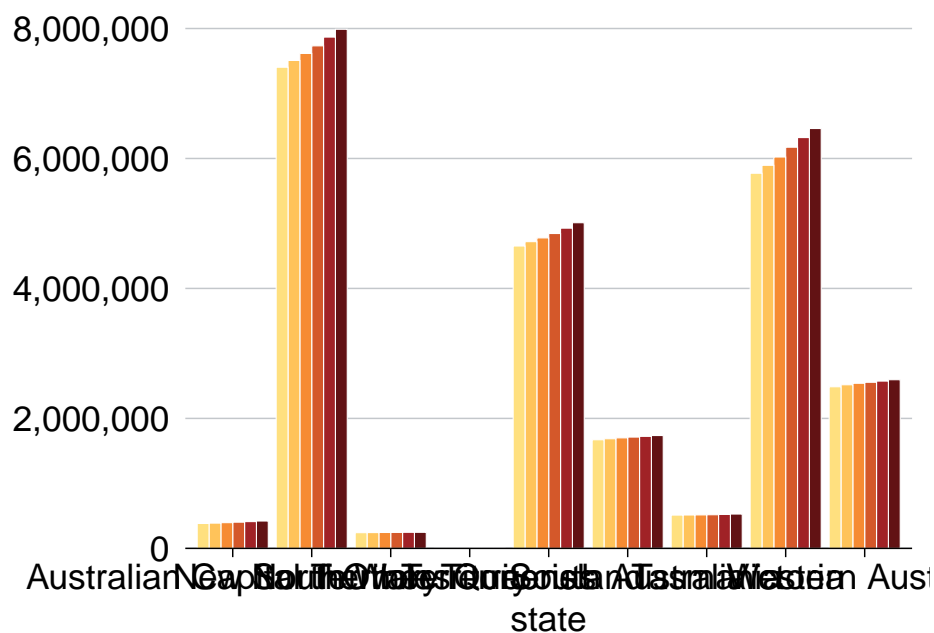
- "count", the default: count the number of observations in a particular group, and plot that number. This is useful when you're using microdata. When this is the case, there is no need for a y aesthetic.
- "sum": sum the values of the y aesthetic.
- "identity": directly report the values of the y aesthetic. This is how Powerpoint and Excel charts work.

You can use `geom_col` instead, as a shortcut for `geom_bar(stat = "identity")`.

Second, `position`, dictates how multiple bars occupying the same x-axis position will be positioned. The options are:

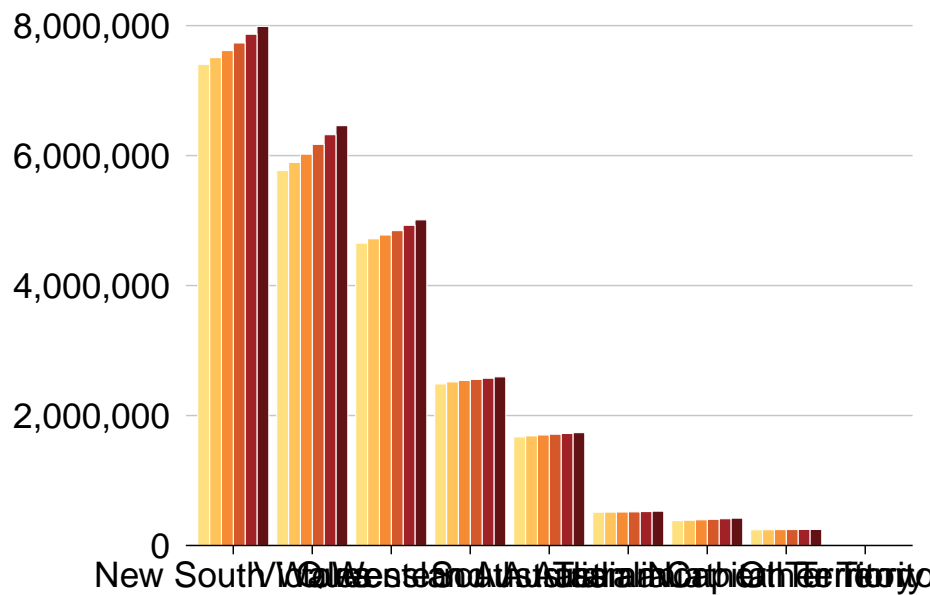
- "stack", the default: bars in the same group are stacked atop one another.
- "dodge": bars in the same group are positioned next to one another.
- "fill": bars in the same group are stacked and all fill to 100 per cent.

```
population_table %>%
  ggplot(aes(x = state,
             y = pop,
             fill = year)) +
  geom_bar(stat = "identity",
           position = "dodge") +
  theme_grattan() +
  grattan_y_continuous(labels = comma) +
  grattan_fill_manual(6)
```



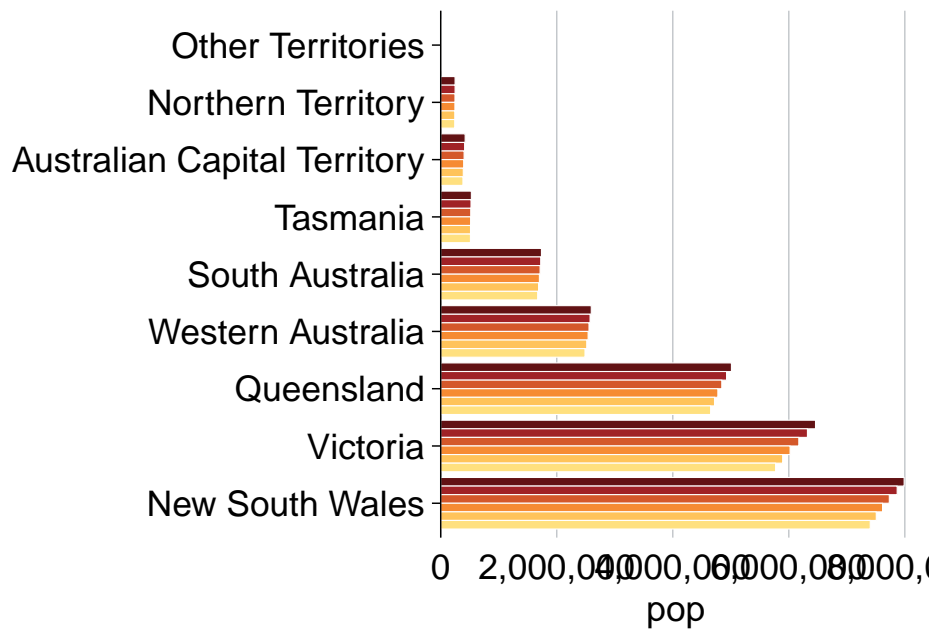
You can also **order** the groups in your chart by a variable. If you want to order states by population, use `reorder` inside `aes`:

```
population_table %>%
  ggplot(aes(x = reorder(state, -pop), # reorder state by negative population
             y = pop,
             fill = year)) +
  geom_bar(stat = "identity",
           position = "dodge") +
  theme_grattan() +
  grattan_y_continuous(labels = comma) +
  grattan_fill_manual(6) +
  labs(x = "")
```



To flip the chart – a useful move when you have long labels – add `coord_flipped` (ie ‘flip coordinates’) and tell `theme_grattan` that the plot is flipped using `flipped = TRUE`.

```
population_table %>%
  ggplot(aes(x = reorder(state, -pop),
              y = pop,
              fill = year)) +
  geom_bar(stat = "identity",
           position = "dodge") +
  coord_flip() + # flip the coordinates
  theme_grattan(flipped = TRUE) + # tell theme_grattan
  grattan_y_continuous(labels = comma) +
  grattan_fill_manual(6) +
  labs(x = "")
```

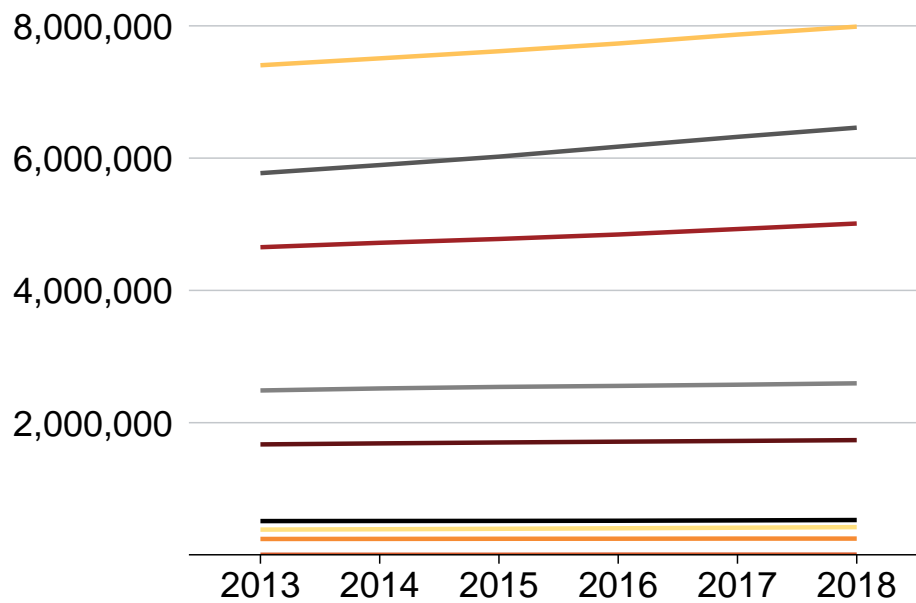


5.4.2 Line charts

A line chart has one key aesthetic: `group`. This tells `ggplot` how to connect individual lines.

```
population_table %>%
  ggplot(aes(x = year,
             y = pop,
             colour = state,
             group = state)) +
  geom_line() +
  theme_grattan() +
  grattan_y_continuous(labels = comma) +
  grattan_colour_manual(9) +
  labs(x = "")
```

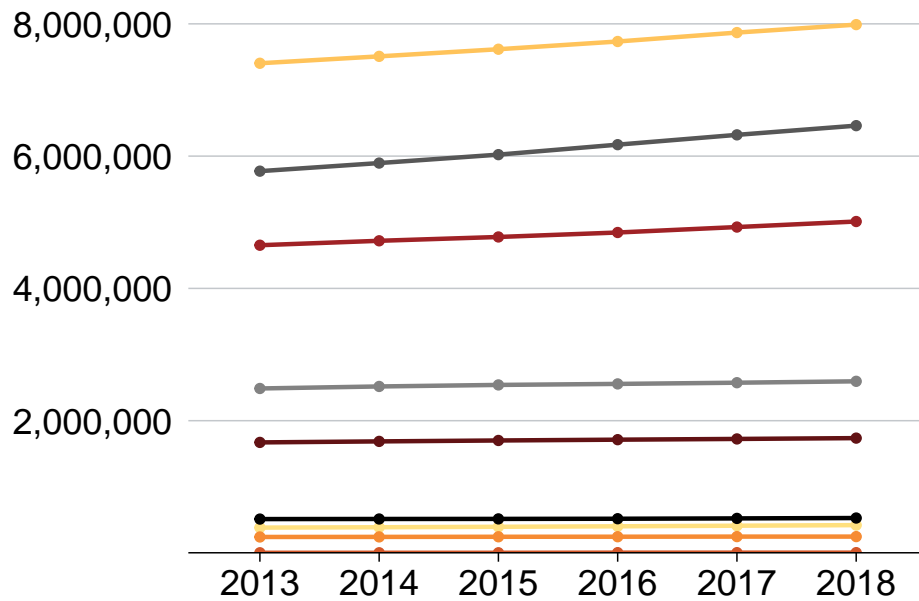
```
## Warning in grattantheme::grattan_pal(n = n, reverse = reverse, faded =
## faded): Using more than six colours is not recommended.
```

You can also add dots for each year by layering `geom_point` on top of `geom_line`:

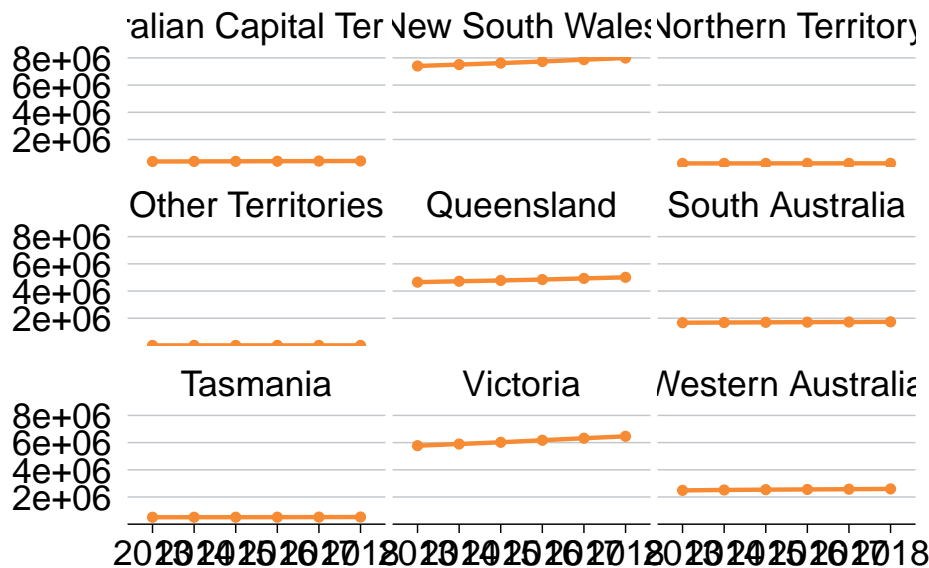
```
population_table %>%
  ggplot(aes(x = year,
             y = pop,
             colour = state,
             group = state)) +
  geom_line() +
  geom_point(size = 2) +
  theme_grattan() +
  grattan_y_continuous(labels = comma) +
  grattan_colour_manual(9) +
  labs(x = "")
```

```
## Warning in grattantheme::grattan_pal(n = n, reverse = reverse, faded =
## faded): Using more than six colours is not recommended.
```



If you wanted to show each state individually, you could **facet** your chart so that a separate plot was produced for each state:

```
population_table %>%
  filter(state != "ACT",
         state != "NT") %>%
  ggplot(aes(x = year,
             y = pop,
             group = state)) +
  geom_line() +
  geom_point(size = 2) +
  theme_grattan() +
  grattan_y_continuous() +
  facet_wrap(state ~ .) +
  labs(x = "")
```



To tidy this up, we can:

1. shorten the years to be “13”, “14”, etc instead of “2013”, “2014”, etc (via the x aesthetic)
2. shorten the y-axis labels to “millions” (via the y aesthetic)
3. add a black horizontal line at the bottom of each facet
4. give the facets a bit of room by adjusting `panel.spacing`
5. define our own x-axis label breaks to just show 13, 15 and 17

```
population_table %>%
  filter(state != "ACT",
         state != "NT") %>%
  ggplot(aes(x = substr(year, 3, 4), # 1: just take the last two characters
            y = pop / 1e6, # 2: divide population by one million
            group = state)) +
  geom_line() +
  geom_point(size = 2) +
  geom_hline(yintercept = 0) + # 3: add horizontal line at the bottom
  theme_grattan() +
  theme(panel.spacing = unit(10, "mm")) + # 4: add panel spacing
  grattan_y_continuous(labels = comma) +
  scale_x_discrete(breaks = c("13", "15", "17")) + # 5: define our own label breaks
  facet_wrap(state ~ .) +
  labs(x = "")
```



5.4.3 Scatter plots

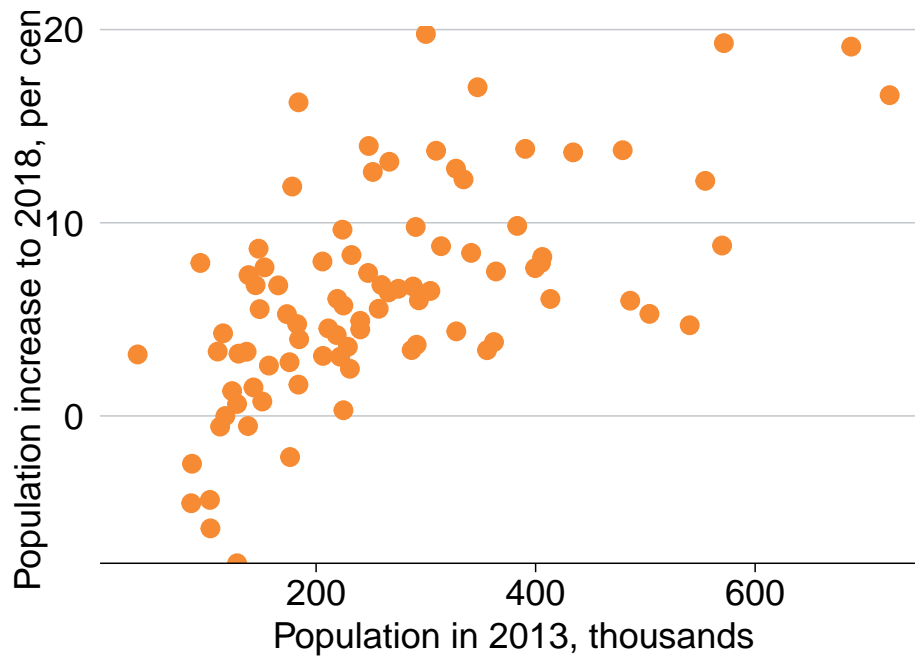
Scatter plots require `x` and `y` aesthetics. These can then be coloured and faceted.

First, create a dataset that we'll use for scatter plots. Take the `population_table` dataset and transform it to have one variable for population in 2013, and another for population in 2018:

```
population_diff <- read_csv("data/population_sa4.csv") %>%
  mutate(state_long = state,
         state = strayr::strayr(state_long),
         pop = as.numeric(value),
         year = as.factor(glue::glue("y{year}"))) %>%
  filter(year %in% c("y2013", "y2018"),
         data_item == "Persons - Total (no.)",
         sa4_name != "Other Territories") %>%
  group_by(year, state, sa4_name) %>%
  summarise(pop = sum(pop)) %>%
  spread(year, pop) %>%
  mutate(pop_change = 100 * (y2018 / y2013 - 1))
```

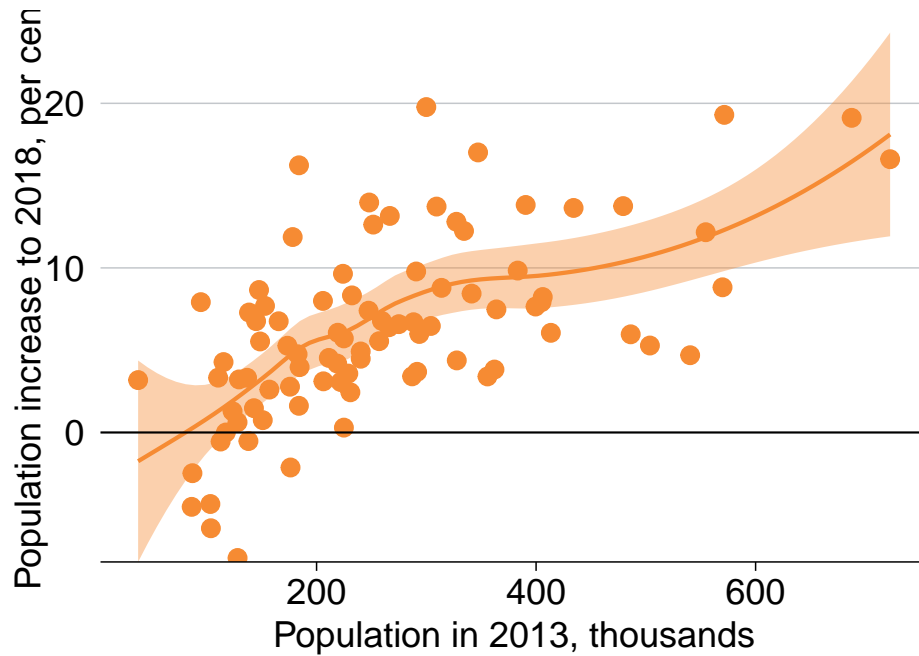
```
population_diff %>%
  ggplot(aes(x = y2013/1000,
            y = pop_change)) +
  geom_point(size = 4) +
```

```
theme_grattan() +
theme(axis.title.y = element_text(angle = 90)) +
grattan_y_continuous() +
labs(y = "Population increase to 2018, per cent",
     x = "Population in 2013, thousands")
```



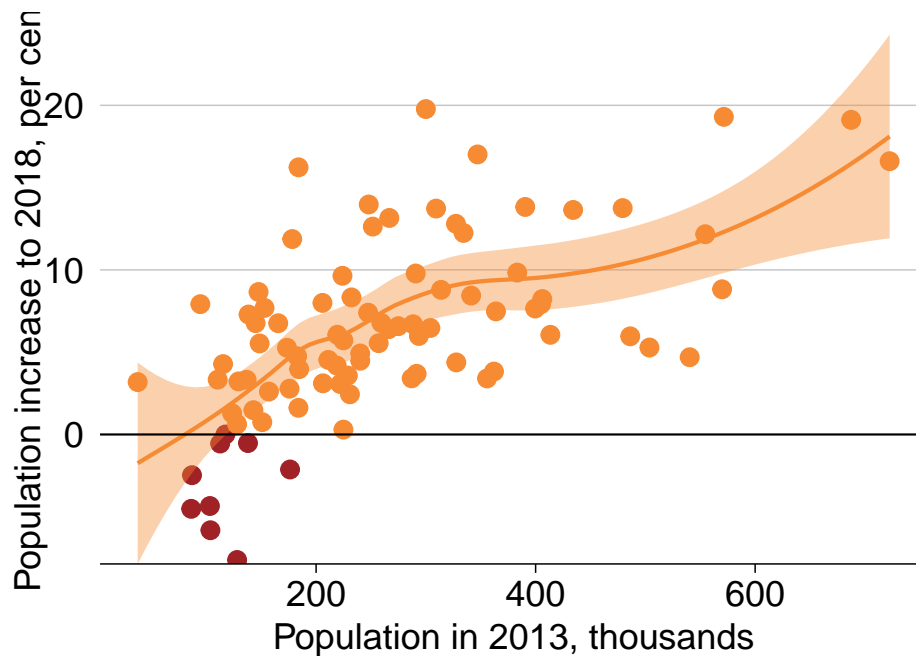
It looks like the areas with the largest population grew the most between 2013 and 2018. To explore the relationship further, you can add a line-of-best-fit with `geom_smooth`:

```
population_diff %>%
  ggplot(aes(x = y2013/1000, # display the x-axis as thousands
             y = pop_change)) +
  geom_point(size = 4) +
  geom_smooth() +
  geom_hline(yintercept = 0) +
  theme_grattan() +
  theme(axis.title.y = element_text(angle = 90)) +
  grattan_y_continuous() +
  labs(y = "Population increase to 2018, per cent",
       x = "Population in 2013, thousands")
```



You could colour-code positive and negative changes from within the `geom_point` aesthetic. Making a change there won't pass through to the `geom_smooth` aesthetic, so your line-of-best-fit will apply to all data points.

```
population_diff %>%
  ggplot(aes(x = y2013/1000, # display the x-axis as thousands
             y = pop_change)) +
  geom_point(aes(colour = pop_change < 0),
             size = 4) +
  geom_smooth() +
  geom_hline(yintercept = 0) +
  theme_grattan() +
  theme(axis.title.y = element_text(angle = 90)) +
  grattan_y_continuous() +
  grattan_colour_manual(2) +
  labs(y = "Population increase to 2018, per cent",
       x = "Population in 2013, thousands")
```



Like the charts above, you could facet this by state to see if there were any interesting patterns. We'll filter out ACT and NT because they only have one and two data points (SA4s) in them, respectively.

```
population_diff %>%
  filter(state != "ACT",
         state != "NT") %>%
  ggplot(aes(x = y2013/1000, # display the x-axis as thousands
             y = pop_change)) +
  geom_point(aes(colour = pop_change < 0),
            size = 2) +
  geom_smooth() +
  geom_hline(yintercept = 0) +
  theme_grattan() +
  theme(axis.title.y = element_text(angle = 90)) +
  grattan_y_continuous() +
  grattan_colour_manual(2) +
  labs(y = "Population increase to 2018, per cent",
       x = "Population in 2013, thousands") +
  facet_wrap(state ~ .)
```



5.4.4 Distributions

```
geom_histogram geom_density
ggribes::
```

5.4.5 Maps

5.4.5.1 `sf` objects

[what is]

5.4.5.2 Using `absmappedata`

The `absmappedata` contains compressed, and tidied `sf` objects containing geometric information about ABS data structures. The included objects are:

- Statistical Area 1 2011: `sa12011`
- Statistical Area 1 2016: `sa12016`
- Statistical Area 2 2011: `sa22011`
- Statistical Area 2 2016: `sa22016`
- Statistical Area 3 2011: `sa32011`
- Statistical Area 3 2016: `sa32016`

- Statistical Area 4 2011: `sa42011`
- Statistical Area 4 2016: `sa42016`
- Greater Capital Cities 2011: `gcc2011`
- Greater Capital Cities 2016: `gcc2016`
- Remoteness Areas 2011: `ra2011`
- Remoteness Areas 2016: `ra2016`
- State 2011: `state2011`
- State 2016: `state2016`
- Commonwealth Electoral Divisions 2018: `ced2018`
- State Electoral Divisions 2018: `sed2018`
- Local Government Areas 2016: `lga2016`
- Local Government Areas 2018: `lga2018`

You can install the package from Github. You will also need the `sf` package installed to handle the `sf` objects.

```
devtools::install_github("wfmackey/absmappedata")
library(absmappedata)

install.packages("sf")
library(sf)
```

5.4.5.3 Making choropleth maps

Choropleth maps break an area into ‘bits’, and colours each ‘bit’ according to a variable.

SA4 is the largest non-state statistical area in the ABS ASGS standard.

You can join the `sf` objects from `absmappedata` to your dataset using `left_join`. The variable names might be different – eg `sa4_name` compared to `sa4_name_2016` – so use the `by` function to match them.

```
map_data <- population_diff %>%
  left_join(sa42016, by = c("sa4_name" = "sa4_name_2016"))

head(map_data %>%
  select(sa4_name, geometry))
```

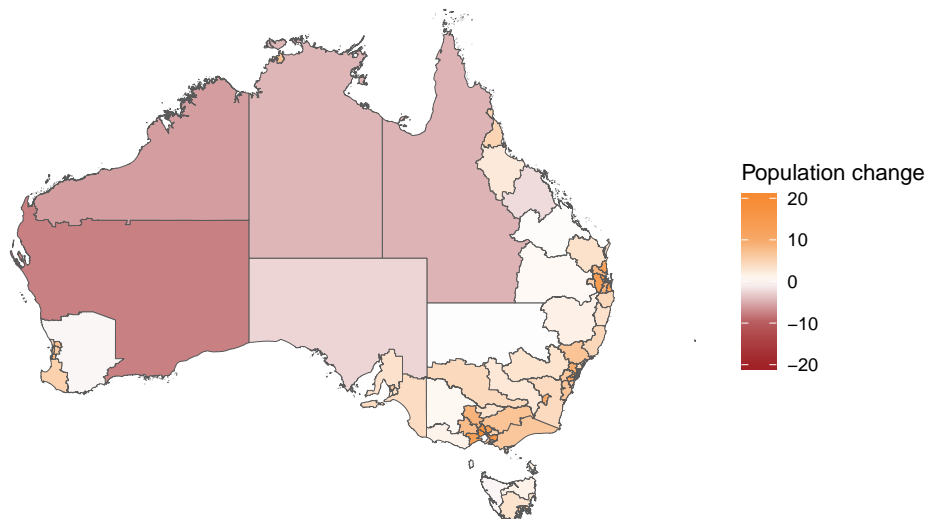
```
## # A tibble: 6 x 3
## # Groups:   state [2]
##   state sa4_name geometry
##   <chr> <chr>      <MULTIPOLYGON [°]>
## 1 ACT   Australian Capita~ (((148.8041 -35.71402, 148.8018 -35.7121, 148.7~
## 2 NSW   Capital Region    (((150.3113 -35.66588, 150.3126 -35.66814, 150.~
```

```
## 3 NSW Central Coast (((151.315 -33.55582, 151.3159 -33.55503, 151.3~
## 4 NSW Central West (((150.6107 -33.06614, 150.6117 -33.07051, 150.~
## 5 NSW Coffs Harbour - G~ (((153.2785 -29.91874, 153.2773 -29.92067, 153.~
## 6 NSW Far West and Orana (((150.1106 -31.74613, 150.1103 -31.74892, 150.~
```

You then plot a map like you would any other `ggplot`: provide your data, choose your `aes` and your `geom`. For maps with `sf` objects, the key **aesthetic** is `geometry = geometry`, and the **geom** is `geom_sf`.

```
map <- map_data %>%
  ggplot(aes(geometry = geometry,
             fill = pop_change)) +
  geom_sf(lwd = 0) +
  theme_void() +
  grattan_fill_manual(discrete = FALSE,
                      palette = "diverging",
                      limits = c(-20, 20),
                      breaks = seq(-20, 20, 10)) +
  labs(fill = "Population change")

map
```



5.5 Creating simple interactive graphs with plotly

```
plotly::ggplotly()
```

5.6 bin: generate data used (before prior sections are constructed)

```
library(tidyverse)
library(janitor)
library(absmapsdata)

data <- read_csv("data/ABS_REGIONAL_ASGS2016_02082019164509969.csv") %>%
  clean_names() %>%
  select(data_code = measure,
         data_item,
         asgs = regiontype,
         sa4_code_2016 = asgs_2016,
         sa4_name_2016 = region,
         year = time,
         value) %>%
  mutate(sa4_code_2016 = as.character(sa4_code_2016)) %>%
  left_join(sa42016 %>% select(sa4_code_2016, state_name_2016)) %>%
  rename(state = state_name_2016,
         sa4_code = sa4_code_2016,
         sa4_name = sa4_name_2016) %>%
  mutate(state_long = state,
         state = strayr::strayr(state_long))

write_csv(data, "data/population_sa4.csv")
```


Chapter 6

Reading data

6.1 Importing data

6.1.1 Reading CSV files

6.1.1.1 `read_csv()`

The `read_csv()` function from the `tidyverse` is quicker and smarter than `read.csv` in base R.

Pitfalls: 1. `read_csv` is quicker because it surveys a sample of the data

We can also compress `.csv` files into `.zip` files and read them *directly* using `read_csv()`:

```
read_csv("data/my_data.zip")
```

This is useful for two reasons:

1. The data takes up less room on your computer; and
2. The original data, which shouldn't ever be directly edited, is protected and cannot be directly edited.

6.1.1.2 `data.table::fread()`

The `fread` function from `data.table` is quicker than both `read.csv` and `read_csv`.

6.1.2 `readxl::read_excel()`

6.1.3 `rio`

6.1.4 `readabs`

6.2 Reading common files:

- TableBuilder CSVSTRINGs
- HES household file
- SIH
- LSAY and derivatives

See data directory for a list of microdata available to Grattan.

6.3 Appropriately renaming variables

As shown in the style guide

Add `rename_abs` function to a common Grattan package?

6.4 Getting to tidy data

`pivot_long()` and `pivot_wide()` *Make sure these are stable btw*

Chapter 7

Different data types

7.1 Tidy data

Other data structures

7.2 Dates with `lubridate::`

The `lubridate::` package

7.3 Strings with `stringr::`

- Replacing values
- Matching values
- Separating columns

7.4 Factors with `forcats::`

- Dangers with factors

Chapter 8

Data transformation

8.1 The pipe

8.2 Key dplyr functions:

All have the same syntax structure, which enable pipe-chains.

8.3 Filter with `filter()`

8.4 Arrange with `arrange()`

8.5 Select variables with `select()`

8.6 Group data with `group_by()`

8.7 Edit and add new variables with `mutate()`

8.7.1 Cases when you should use `case_when()`

8.8 Summarise data with `summarise()`

8.9 Joining datasets with `*_join()`

Chapter 9

Analysis

Chapter 10

Creating functions

10.1 It can be useful to make your own function

Why on earth would you create your own function?

10.2 Defining simple functions

10.3 More complex functions

10.4 Sets of functions

10.5 Using `purrr::map`

10.6 Sharing your useful functions with Grattan

Chapter 11

Version control

11.1 Version control is important and intimidating

Version control is great!

11.2 Github

We use Github to version-control and share reports in LaTeX, so you're already a bit set-up.

11.3 Git

Using Git within R Studio...