Taking control of graphics using R

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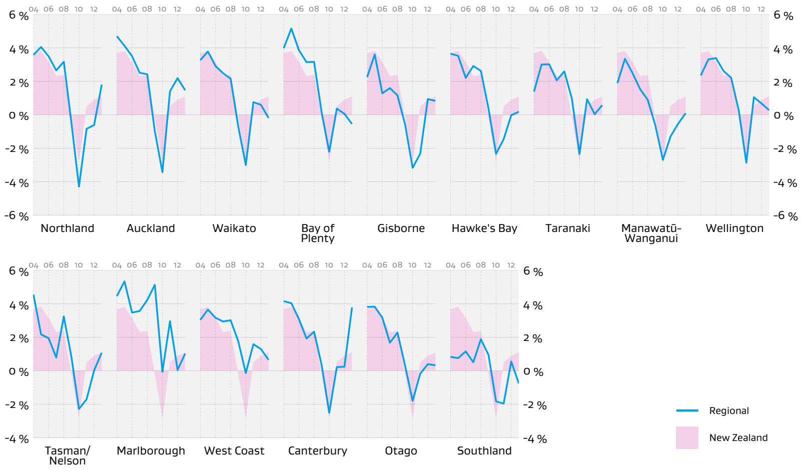
Outline

Some examples of plots I created for the New Zealand Ministry of Business, Innovation & Employment

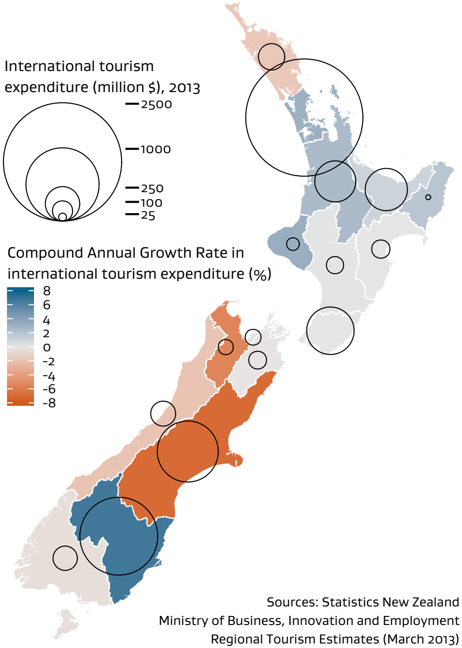
- All made using programming only (except logos)
- Only using R
- The scripts will be made public after report completion

Annual employment growth in the regions versus New Zealand - 2003-2013



Source: Employment Estimates, MBIE

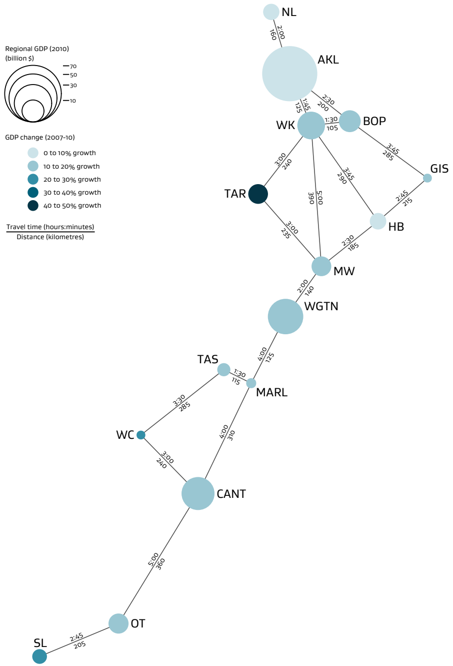
Compound Annual Growth Rate in international tourism expenditure, 2009-2013



International tourism expenditure (million $), 2013
2500
1000
250
100
25
Compound Annual Growth Rate in international tourism expenditure (%)
8
6
4
2
0
-2
-4
-6
-8

Sources: Statistics New Zealand
Ministry of Business, Innovation and Employment
Regional Tourism Estimates (March 2013)

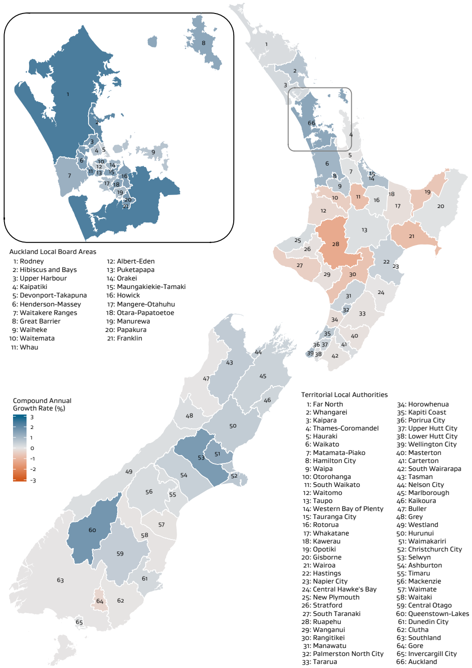
Current travel time and GDP growth



Note: Separation of regional centres is proportional to travel time

Source: New Zealand Transport Agency, Automobile Association, Statistics New Zealand

Average annual growth (%) in population by TLA - 2013-2031



Auckland Local Board Areas

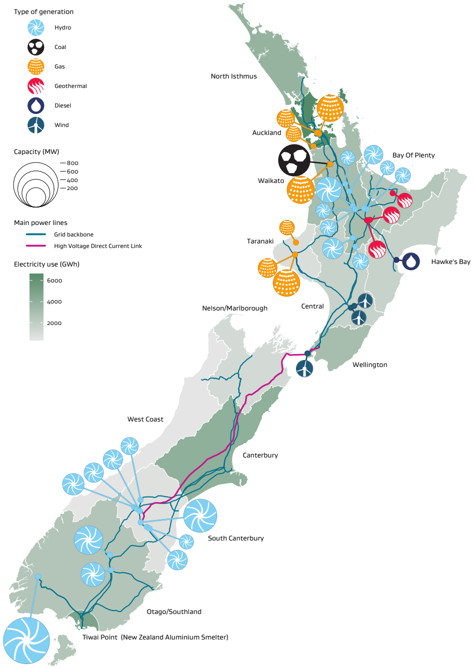
1: Rodney	12: Albert-Eden
2: Hibiscus and Bays	13: Puketapapa
3: Upper Harbour	14: Orakei
4: Kaipatiki	15: Maungakiekie-Tamaki
5: Devonport-Takapuna	16: Howick
6: Henderson-Massey	17: Mangere-Otahuhu
7: Waitakere Ranges	18: Otara-Papatoetoe
8: Great Barrier	19: Manurewa
9: Waiheke	20: Papakura
10: Waitemata	21: Franklin
11: Whau	

Territorial Local Authorities

1: Far North	34: Horowhenua
2: Whangarei	35: Kapiti Coast
3: Kaipara	36: Porirua City
4: Thames-Coromandel	37: Upper Hutt City
5: Hauraki	38: Lower Hutt City
6: Waikato	39: Wellington City
7: Matamata-Piako	40: Masterton
8: Hamilton City	41: Carterton
9: Waipa	42: South Wairarapa
10: Otorohanga	43: Tasman
11: South Waikato	44: Nelson City
12: Waitomo	45: Marlborough
13: Taupo	46: Kaikoura
14: Western Bay of Plenty	47: Buller
15: Tauranga City	48: Grey
16: Rotorua	49: Westland
17: Whakatane	50: Hurunui
18: Kawerau	51: Waimakariri
19: Opotiki	52: Christchurch City
20: Gisborne	53: Selwyn
21: Wairoa	54: Ashburton
22: Hastings	55: Timaru
23: Napier City	56: Mackenzie
24: Central Hawke's Bay	57: Waimate
25: New Plymouth	58: Waitaki
26: Stratford	59: Central Otago
27: South Taranaki	60: Queenstown-Lakes
28: Ruapehu	61: Dunedin City
29: Wanganui	62: Clutha
30: Rangitikei	63: Southland
31: Manawatu	64: Gore
32: Palmerston North City	65: Invercargill City
33: Tararua	66: Auckland

Source: Population estimates and population projections, Statistics New Zealand

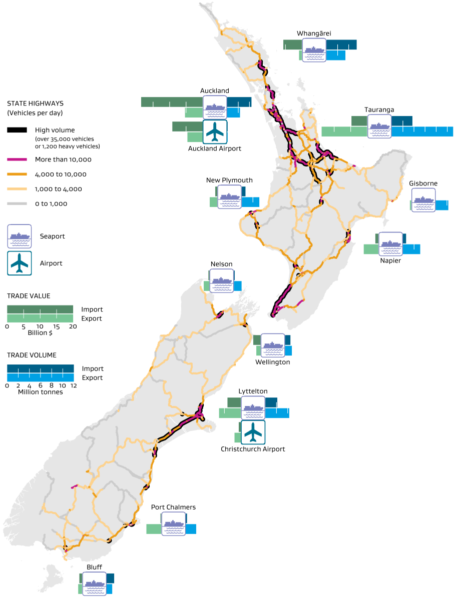
Electricity infrastructure and use by region - 2013



Note: Only the largest power plants are represented, accounting for 90% of the national production

Source: Electricity Authority, Transpower New Zealand

Major New Zealand transport network connections 2013



Sources: New Zealand Transport Agency, Statistics New Zealand
Adjustments for transhipment by sea were made by the Ministry of Transport

Programming vs. hand drawing

Programming may seem tedious but

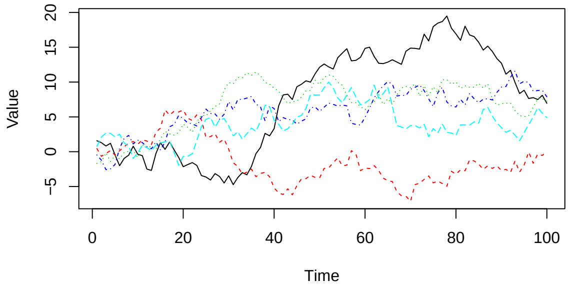
- Plots are easy to update with new data
- Code is easy to re-use and adapt (use **GNU make** for work flow management)
- Easily scalable (no difference between 5 regions or 10,000)
- Changes are easy to track (use **GIT** for version control)
- Transparent
- Guarantee that the plot reflects the data
    - No hand tweaking of e.g. bubble sizes or region colours
    - What you see is directly derived from the original data

Simple R graphics

Improving from R base graphics

Simple plots in R are quick and easy, but lack finesse...

```r
par(mar=c(4,4,.5,.5))
matplot(apply(matrix(rnorm(500), nrow=5), 1, cumsum),
        xlab='Time', ylab='Value', type='l')
```

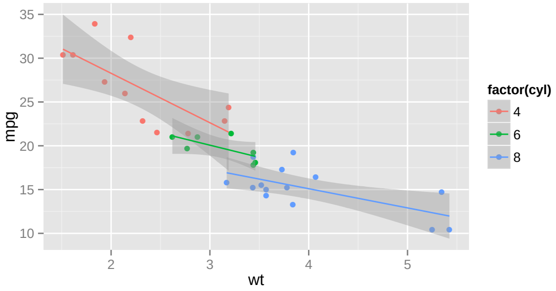


Improved R graphics

Improving from R base graphics

ggplot2 provides a consistent visual style (grammar of graphics), but it constrains you.

```
library(ggplot2)
ggplot(mtcars, aes(x=wt, y=mpg, col=factor(cyl))) + geom_point() +
    geom_smooth(aes(group=cyl), method='lm') +
    theme(plot.margin=unit(c(0,0,0,0),'line'))
```



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Customised R graphics

Improving from R base graphics

ggplot2 can still be used for making customised graphics, especially by using the power of grid graphics

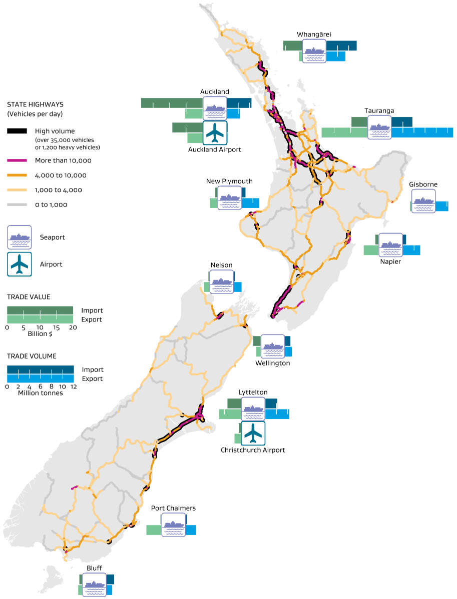
Customisation is needed when:

- A specific style or design is required (client, journal, organisation, ...)
- Fitting a lot of information in a single figure
- Plots are infographics

Many libraries are available. See http://cran.r-project.org/web/views/Graphics.html

Focus here on ggplot2 and grid, and a single plot

Major New Zealand transport network connections 2013



Sources: New Zealand Transport Agency, Statistics New Zealand
Adjustments for transhipment by sea were made by the Ministry of Transport

Preparation

Data

Several sources:

- GIS shapefiles (NZ coastline, road networks)
- Spreadsheet with port locations and position tweaks (manual)
- Spreadsheets with import/export values and volumes

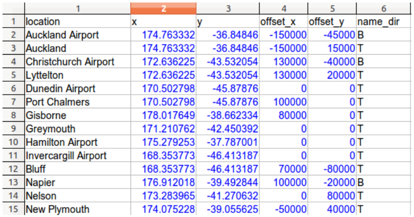
Shapefiles

```r
library(rgdal)
nz <- readOGR("gis_folder", "nz-coastline",
              p4s="+init=epsg:4326")  ## lat/long projection
## Project to NZTM (in metres)
nz <- spTransform(nz, CRS("+init=epsg:2193"))

## Fortify - Converts spatial object to a data frame of
##  x and y coordinates usable by ggplot
library(ggplot2)
nz <- fortify(nz)
save(nz, file='nz-coastline-nztm.rdata')
```

Spreadsheets

Data



	1	2	3	4	5	6
1	location	x	y	offset_x	offset_y	name_dir
2	Auckland Airport	174.763332	-36.84846	-150000	-45000	B
3	Auckland	174.763332	-36.84846	-150000	15000	T
4	Christchurch Airport	172.636225	-43.532054	130000	-40000	B
5	Lyttelton	172.636225	-43.532054	130000	20000	T
6	Dunedin Airport	170.502798	-45.87876	0	0	T
7	Port Chalmers	170.502798	-45.87876	100000	0	T
8	Gisborne	178.017649	-38.662334	80000	0	T
9	Greymouth	171.210762	-42.450392	0	0	T
10	Hamilton Airport	175.279253	-37.787001	0	0	T
11	Invercargill Airport	168.353773	-46.413187	0	0	T
12	Bluff	168.353773	-46.413187	70000	-80000	T
13	Napier	176.912018	-39.492844	100000	-20000	B
14	Nelson	173.283965	-41.270632	0	80000	T
15	New Plymouth	174.075228	-39.055625	-50000	40000	T

```r
ports_loc <- read.csv('ports-locations.csv', as.is=T)

library(sp)
coordinates(ports_loc) <- ~ x + y
proj4string(ports_loc) <- "+init=epsg:4326"
ports_loc <- as.data.frame(spTransform(ports_loc, CRS("+init=epsg:2193")))
```

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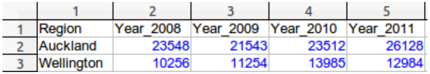
Spreadsheets

Data

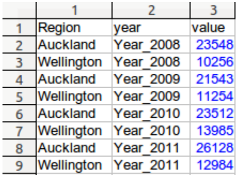
Normalise data to have only one row per "point"

Not:



	1	2	3	4	5
1	Region	Year_2008	Year_2009	Year_2010	Year_2011
2	Auckland	23548	21543	23512	26128
3	Wellington	10256	11254	13985	12984

But:



	1	2	3
1	Region	year	value
2	Auckland	Year_2008	23548
3	Wellington	Year_2008	10256
4	Auckland	Year_2009	21543
5	Wellington	Year_2009	11254
6	Auckland	Year_2010	23512
7	Wellington	Year_2010	13985
8	Auckland	Year_2011	26128
9	Wellington	Year_2011	12984

```
library(reshape2)
melt(data, id.vars='Region', variable.name='year')
```

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Plot NZ coastline, and road networks:

```r
p <- qplot(xlims, ylims, geom = "blank") +
    geom_polygon(aes(x=long, y=lat, group=id), fill=colour_nz, colour=NA,
                 data=nz) +
    geom_path(aes(x=long, y=lat, group=group), data=hightraff,
              size=2.5*size_large_roads, colour='black') +
    geom_path(aes(x=long, y=lat, group=group, colour=traff), data=traff,
              size=size_large_roads) +
    scale_colour_manual(values = routes_cols, guide='none') +
    coord_fixed(ratio=1, xlim=xlims, ylim=ylims) +
    theme_blank()
```

`xlims, ylims, colour_nz, size_large_roads` are variables defined at the beginning of script

`routes_cols` is a named vector relating discrete values of route traffic to their colour

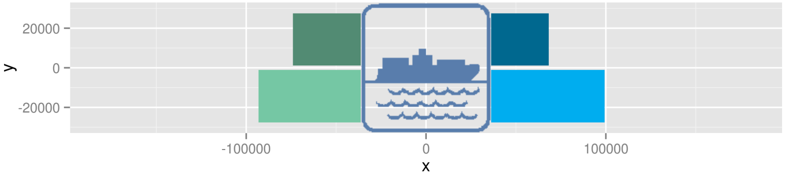
Subplot creation

Subplots

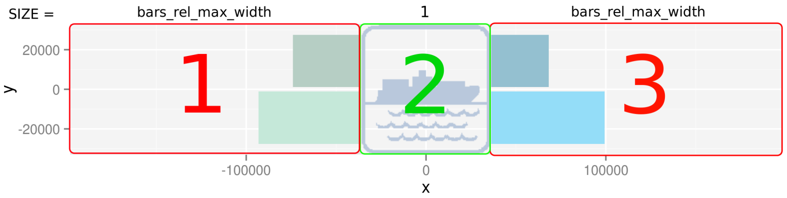
Subplot creation

Subplots

Without theme



Three viewports



```r
boat_grob <- rasterGrob(readPNG('boat-logo.png'))

pushViewport(
  viewport(layout = grid.layout(1, 3,
    widths = unit(c(bars_rel_max_width, 1, bars_rel_max_width),
      rep('grobwidth',3), list(boat_grob, boat_grob, boat_grob)),
    heights = grobHeight(boat_grob))))
```

Viewports

Subplots

One of the two bar plots:

```r
bars_vol <- ggplot(vol, aes(x=import_export, y=value, fill=import_export)) +
    geom_bar(stat='identity', width=1-gap_between_bars) +
    scale_fill_manual(guide='none', values=c(import=colour_bar_imp_vol,
                                             export=colour_bar_exp_vol)) +
   coord_flip(ylim=c(0, max.vol)) +  # make bars horizontal and set limits
    scale_y_continuous(expand=c(0,0)) +   # remove gaps
    theme_nothing()
```

Add it to viewport 3:

```r
pushViewport(viewport(layout.pos.row = 1, layout.pos.col = 3))
grid.draw(ggplotGrob(bars_vol))
upViewport()
```

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Adding subplot to main plot

Subplots

```
subplot <- grid.grabExpr({
              pushViewport(...)
              grid.draw(...)
              ... })

subplot_width <- (2*bars_rel_max_width + 1)*subplot_size

p1 <- p + annotation_custom(subplot,
          xmin = loc_x - subplot_width/2, xmax = loc_x + subplot_width/2,
           ymin = loc_y - subplot_size/2, ymax = loc_y + subplot_size/2)
```

Adding grid object in user coordinates

Example: add a reference scale for the bar plots (a rectangle the width of the longest bar)

```r
g <- ggplot(...)
print(g)

downViewport('panel.3-4-3-4')
gb <- ggplot_build(g)
pushViewport(dataViewport(xscale=gb$panel$ranges[[1]]$x.range,
                          yscale=gb$panel$ranges[[1]]$y.range,
                          clip='off'))

grid.rect(x = unit(x_coord, 'native'),
          y = unit(y_coord, 'native'),
          width = unit(subplot_size * bars_rel_max_width, 'native'),
          height = unit(0.5, 'cm'))
```

Adding grid object in user coordinates

Grid offers many primitive shapes for adding to plots

- grid.rect(), grid.lines(), grid.text(), grid.arrows(), ...

Different units can be conveniently combined (i.e., for adding spacing):

```
grid.text(x = unit(coord_x, 'native') + unit(3, 'mm'), ...)
```

Styling with ggplot

Use `theme`

```
ggplot(...) +
  theme(axis.ticks.length = unit(1.5, "mm"),
        panel.background = element_blank())
```

Or replace geoms with your own function to use consistent formats:

```
title_text <- function(...)
    geom_text(..., size=10, family='Helvetica',lineheight=0.8)

ggplot(...) + title_text('This is a title')
```

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Styling with grid

Use gpar

```r
grid.rect(gp = gpar(col='red', fill=NA, lwd=2))
```

Also make use of functions for consistency

```r
gpar_title <- function(...)
    gpar(fontsize=10, fontfamily='Helvetica', lineheight=0.8, ...)

grid.text('This is a title', gp=gpar_title())
```

Thank you

This presentation and a self-contained project for making the main plot are publicly available on GitHub:

https://github.com/dragonfly-science/r-users-group-presentation

Thank you to the whole R and open-source community for making this possible.

Main software used: R, LaTeX, Beamer, GNU make, GIT, Emacs

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