

Bivariate Mapping with R

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Introduction

This is a brief introduction on how to create bivariate maps in R. Based on the fake data, we will create a bivariate map using `ggplot2` and `biscate` package (Prener, Grossenbacher, and Zehr 2022). Some code will also help with data cleaning and data preparation by `tidyverse` in the context of geographical data in Australia. As the legend is a bit tricky in bivariate maps, we will also introduce `ggpubr` for create bivariate maps annotated with legend.

Part 1 Data Preparation

1.1 Library packages

First, we need to library the necessary packages. `tidyverse` is a collection of R packages designed for data science. `spdep` is a package for spatial data. `ggpubr` is a package for creating complex plots. `biscale` is a package for creating bivariate maps. `readxl` is a package for reading excel files.

```
library(tidyverse)
library(readxl)
library(spdep)
library(ggpubr)
library(biscale)
```

1.2 Read Data

Then, we need to load the data and the map. The data is a fake dataset that contains the Count value and the MMM categorized in 7 groups. The map is the shape file in SA3 levels of Australia published under ASGS2021 (ABS 2021).

```
data_fake <- read_excel("Data/Fake data for Emily Ranger project.xlsx") %>%
  mutate(SA3_CODE = as.character(SA3_CODE)) %>%
  mutate(SA3_CODE = replace(SA3_CODE, SA3_CODE == "31095", "31905")) %>%
  # correct some wrong SA3CODE
  mutate(SA3_NAME = replace(SA3_NAME,
                             SA3_NAME == "Bowen Basin - North",
                             "Bowen Basin - North"),
         SA3_NAME = replace(SA3_NAME,
                             SA3_NAME == "Cairns - South",
                             "Cairns - South"),
         SA3_NAME = replace(SA3_NAME,
                             SA3_NAME == "Darling Downs - East",
                             "Darling Downs - East"),
         SA3_NAME = replace(SA3_NAME,
                             SA3_NAME == "Outback - South",
                             "Outback - South")) %>%
  # correct some wrong SA3NAME
  rename(SA3_NAME21 = SA3_NAME,
         SA3_CODE21 = SA3_CODE)
```

Here as we noticed that the SA3_CODE “31095” should be “31905”. We also correct some wrong SA3_CODE. We also correct some wrong SA3_NAME. We rename the columns to SA3_NAME21 and SA3_CODE21 as it is the official name in the map file from ASGS2021.

1.3 Load Map

```
SA3_map <- st_read("Maps/SA3_2021_AUST_GDA2020.shp",  
                  quiet = TRUE) %>%  
  left_join(data_fake)
```

Joining with `by = join_by(SA3_CODE21, SA3_NAME21)`

Here we load the map file and join it with the fake data.

Part 2 Bivariate Mapping

2.1 Define Biscle Categories

We need to define the bivariate categories for the bivariate map. We will use the `bi_class` function from the `biscle` package. We will categorize the Count into 4 quantiles and the MMM into 4 categories.

Here we use the `ntile` function to categorize the Count into 4 quantiles. We use the `cut` function to categorize the MMM into 4 categories. We also use the `if_else` function to replace the value of 1 in MMM with NA. So that the four categories of MMM will be 2-3, 4-5, 6, and 7.

For the area with no data, `bi_class` will produce NA-NA value.

```
map_data <- SA3_map %>%  
  mutate(Count_cat = factor(ntile(Count, 4),  
                             labels = c("Q1 ", "Q2", "Q3", "Q4")),  
         MMM_cat = if_else(MMM == 1, NA, MMM),  
         MMM_cat = cut(MMM_cat,  
                       breaks = c(-Inf, 3, 5, 6, Inf),  
                       labels = c("2-3", "4-5", "6", "7")) %>%  
  bi_class(x = Count_cat, y = MMM_cat, dim = 4)
```

2.2 Create Bivariate Map

Now we can create the bivariate map using `ggplot2` and `biscale` package. We use the `geom_sf` function to plot the map. We use the `bi_scale_fill` function to add the bivariate color scale. We use the `bi_theme` function to add the theme. We also change the font size of the title using the `theme` function as the default font size is too large.

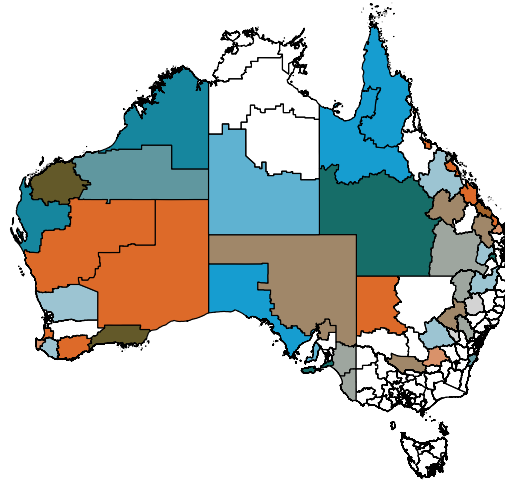
Here we choose the “BlueOr” color palette. For more choices of color palettes, you can check the `biscale` package documentation [here](#).

We also need to hide the legend as the default legend is not suitable for bivariate maps.

```
main_map <- map_data %>%
  ggplot() +
  geom_sf(aes(fill = bi_class),
          color = "black",
          show.legend = FALSE) +
  # Need to hide legend as the default legend is not suitable for bivariate map
  bi_scale_fill(pal = "BlueOr",
                dim = 4,
                na.value = NA) +
  labs(title = "Bivariate Map of Australia") +
  bi_theme() +
  theme(plot.title = element_text(size = 14,
                                   face = NULL,
                                   family = "sans"))

main_map
```

Bivariate Map of Australia

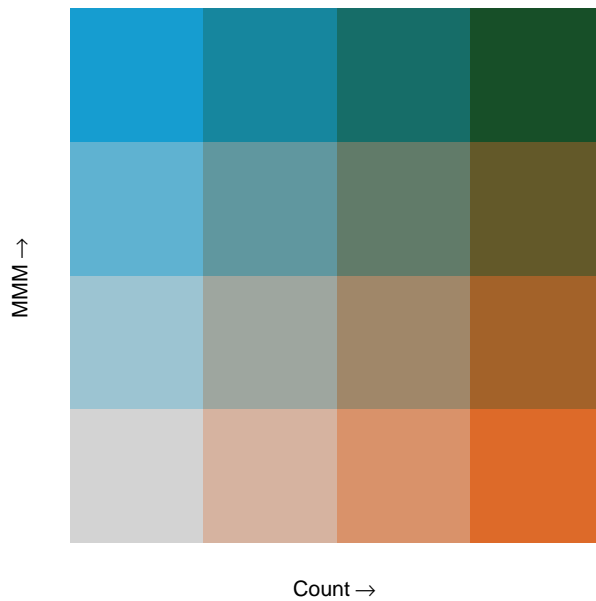


2.3 Create suitable legend

As the legend is a bit tricky in bivariate maps, we will use `bi_legend` function from the `biscale` package to create a suitable legend. We use the `pal` argument to specify the color palette. We use the `dim` argument to specify the number of categories. We use the `xlab` and `ylab` arguments to specify the labels for the x-axis and y-axis, and the `size` argument to specify the font size of the legend.

```
legend <- bi_legend(pal = "BlueOr",  
  dim = 4,  
  xlab = "Count",  
  ylab = "MMM",  
  size = 8)
```

```
legend
```

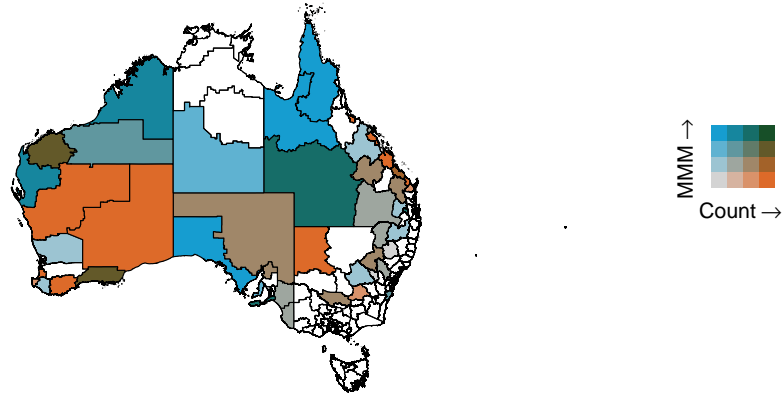


2.4 Combine Map and Legend

Now, we can use the `ggarrange` function from the `ggpubr` package to combine the bivariate map and the legend. We use the `widths` argument to specify the ratio of the width of the map and the legend.

```
final_map <- ggarrange(main_map, legend,  
  nrow = 1, ncol = 2,  
  widths = c(5,1))  
  
final_map
```

Bivariate Map of Australia



2.5 Save the Map

Finally, we can save the bivariate map using the `ggsave` function. We use the `filename` argument to specify the file path and name. We use the `height` and `width` arguments to specify the height and width of the plot.

```
ggsave(plot = final_map,  
       filename = str_c("final_map.png"),  
       height = 16,  
       width = 16,  
       units = "cm")
```

References

- ABS. 2021. "Australian Statistical Geography Standard (ASGS) Edition 3." Australian Bureau of Statistics. <https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026>.
- Prener, Christopher, Timo Grossenbacher, and Angelo Zehr. 2022. *Biscale: Tools and Palettes for Bivariate Thematic Mapping*. <https://chris-prener.github.io/biscale/>.