

# Data Viz III: Geographic Mapping with ggplot2

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## Description

In this class, we will explore how to create geographic maps using `ggplot2`, `sf`, `maps`, `leaflet`, and `geojson`. We'll cover techniques for plotting data points on US and Canada maps, customizing map aesthetics, and working with spatial data.



## 1 Learning Objectives

By the end of this session, you will: 1. Load and visualize geographic data using `sf` and `maps`. 2. Create US and Canada maps using `ggplot2`. 3. Overlay data points on maps using geographic coordinates. 4. Customize map aesthetics for professional presentations. 5. Work with shapefiles and GeoJSON for more detailed geographic visualizations. 6. Implement a function for plotting. 7. Create an interactive map using `leaflet`.

### Required Packages

Ensure the following packages are installed:

```
library(pacman)
p_load(ggplot2, sf, maps, dplyr,
       ggthemes, ggrepel, leaflet, geojsonio,
       ggspatial, ggpubr)
```

## 2 Introduction to Mapping with ggplot2 and maps

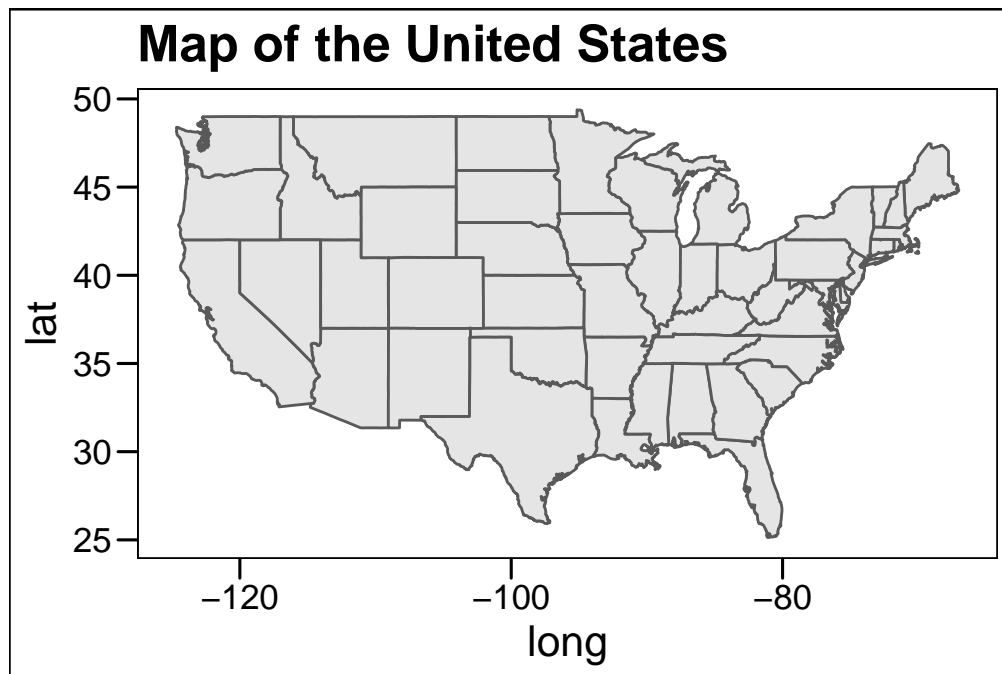
We will start by creating basic maps of the US and Canada using the `maps` package.

### 2.1 US Map with State Boundaries

```
# Load US map data
us_map <- map_data("state")

# Plot US map
us_plot <-
  ggplot() +
    geom_polygon(data = us_map, aes(x = long, y = lat, group = group),
                 fill = "grey90", color = "grey35") +
    coord_fixed(1.3) +
    labs(title = "Map of the United States") +
    theme_base()

us_plot
```



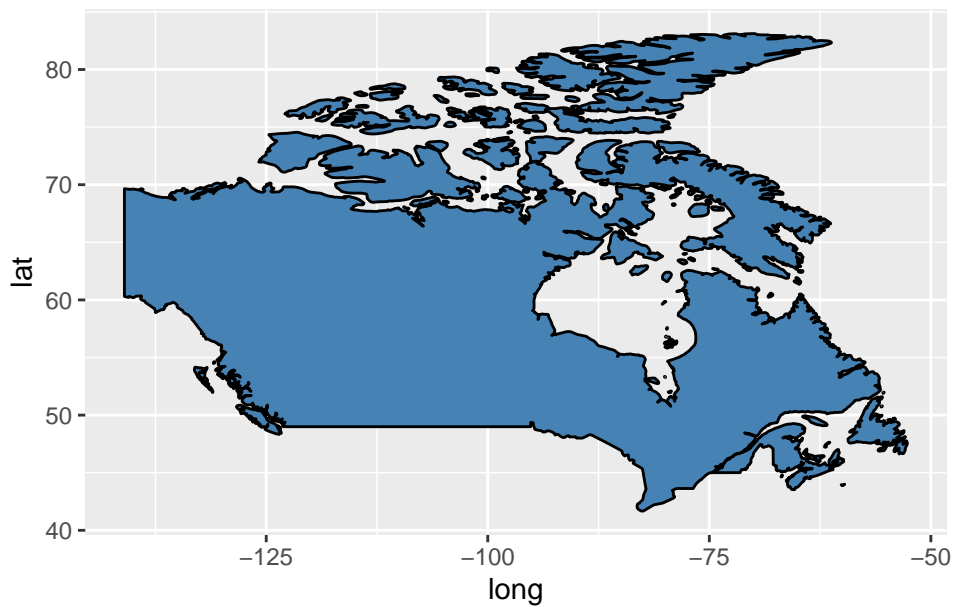
## 2.2 Canada Map with Provincial Boundaries

```
# Load Canada map data
canada_map <- map_data("world", region = "Canada")

# Plot Canada map
canada_plot <- ggplot() +
  geom_polygon(data = canada_map, aes(x = long, y = lat, group = group),
    fill = "steelblue", color = "black") +
  coord_fixed(1.3) +
  labs(title = "Map of Canada")

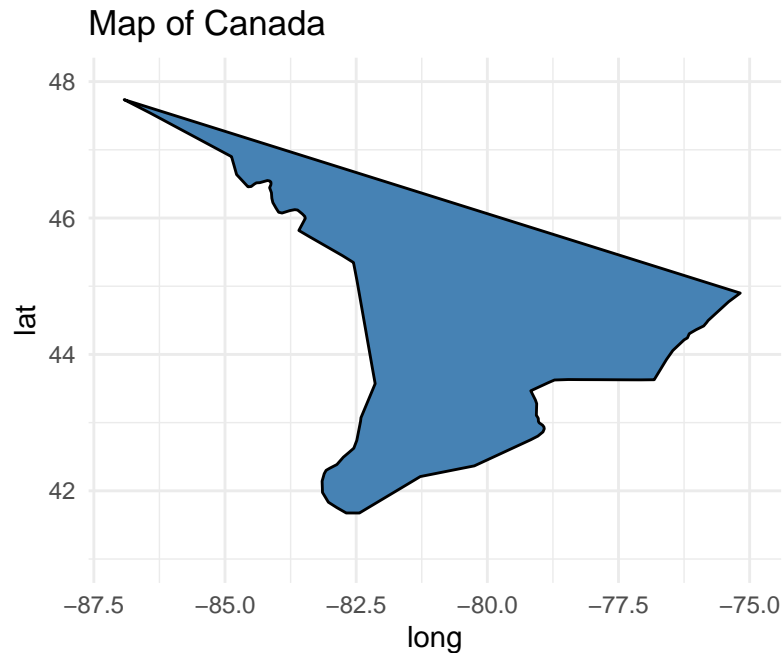
canada_plot
```

Map of Canada



```
canada_cut <- canada_plot +  
  # Cut limits of map  
  scale_y_continuous(limits = c(41, 48))+  
  scale_x_continuous(limits = c(-87, -75))+  
  theme_minimal()
```

```
canada_cut
```



### 3 Plotting Data Points on Maps

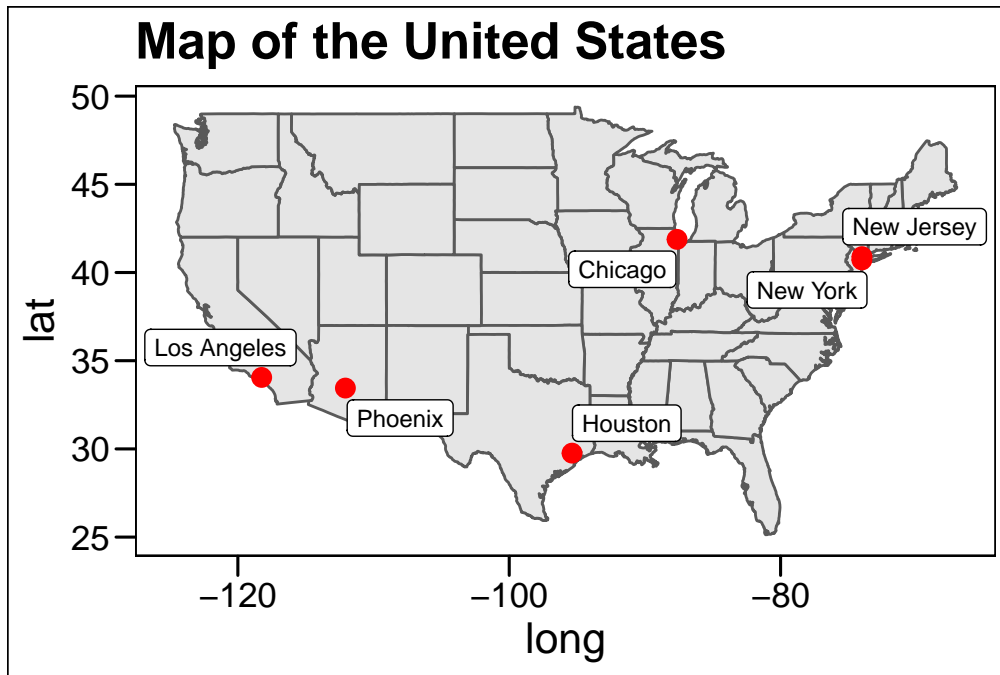
Next, we'll plot specific data points (e.g., cities) on the US and Canada maps.

#### 3.1 Plotting Cities on US Map

```
# Sample city data
cities_us <- data.frame(
  city = c("New Jersey", "New York", "Los Angeles", "Chicago", "Houston", "Phoenix"),
  lon = c(-74, -74.006, -118.2437, -87.6298, -95.3698, -112.074),
  lat = c(40.9, 40.7128, 34.0522, 41.8781, 29.7604, 33.4484)
)

# Plot US map with cities
us_plot +
  geom_point(data = cities_us, aes(x = lon, y = lat),
    color = "red", size = 3) +
  # geom_label(data = cities_us, aes(x = lon, y = lat, label = city),
  #   size = 3, color = "black")
```

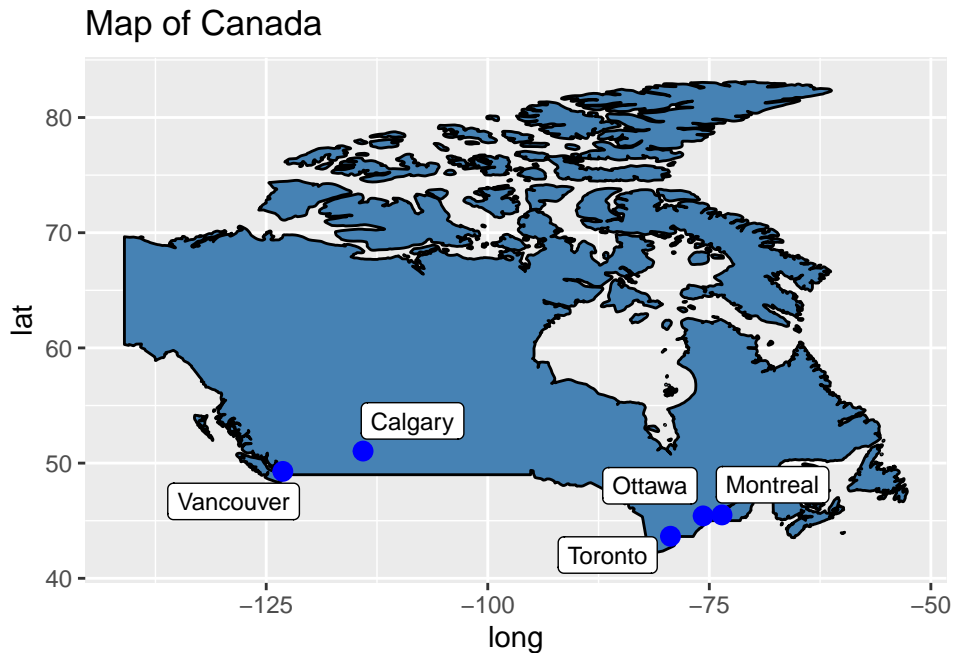
```
geom_label_repel(data = cities_us, aes(x = lon, y = lat, label = city),
  size = 3, color = "black")
```



### 3.2 Plotting Cities on Canada Map

```
# Sample city data for Canada
cities_canada <- data.frame(
  city = c("Toronto", "Vancouver", "Montreal", "Calgary", "Ottawa"),
  lon = c(-79.3832, -123.1216, -73.5673, -114.0719, -75.6972),
  lat = c(43.6511, 49.2827, 45.5017, 51.0447, 45.4215)
)

# Plot Canada map with cities
canada_plot +
  geom_point(data = cities_canada, aes(x = lon, y = lat),
    color = "blue", size = 3) +
  geom_label_repel(data = cities_canada, aes(x = lon, y = lat, label = city),
    size = 3, color = "black")
```



## 4 Mapping with Shapefiles using `sf`

For more detailed geographic visualizations, we can use shapefiles with the `sf` package.

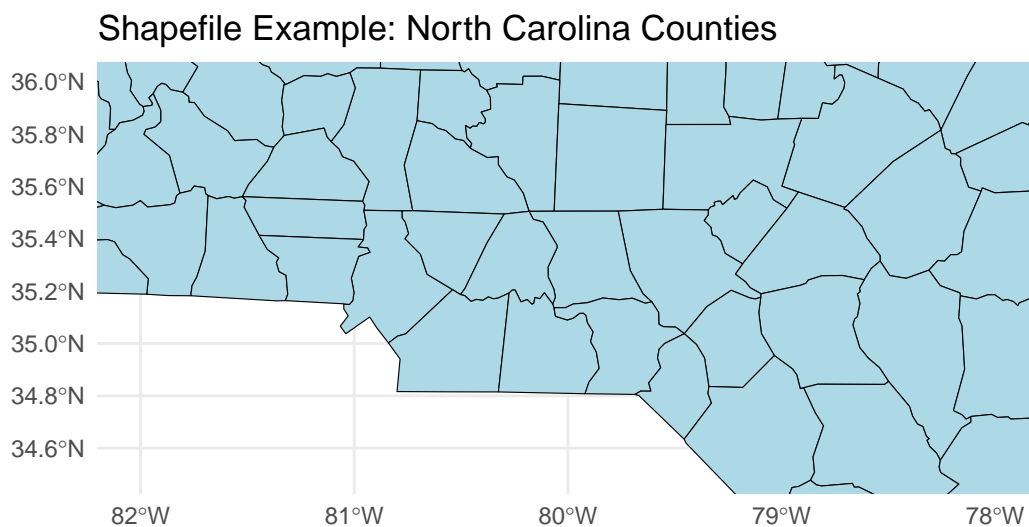
### 4.1 Loading and Plotting Shapefiles

```
# Load shapefile (replace 'path_to_shapefile' with your actual path)
# usa_shapefile <- st_read("path_to_shapefile/usa_shapefile.shp")

# Example using built-in dataset from `sf`
nc <- st_read(system.file("shape/nc.shp", package = "sf"))
```

```
Reading layer `nc` from data source
  `/Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/library/sf/shape/nc.shp'
  using driver `ESRI Shapefile'
Simple feature collection with 100 features and 14 fields
Geometry type: MULTIPOLYGON
Dimension:      XY
Bounding box:   xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax: 36.58965
Geodetic CRS:  NAD27
```

```
# Plot shapefile
ggplot(nc) +
  geom_sf(fill = "lightblue", color = "black") +
  labs(title = "Shapefile Example: North Carolina Counties") +
  # Adjust scales for limits
  scale_y_continuous(limits = c(34.5, 36)) +
  scale_x_continuous(limits = c(-82, -78)) +
  theme_minimal()
```



## 4.2 Read shp of Canada and US

```
## Load shp files
usa_shp <- st_read("shp_map/us/usa.shp") %>%
  # Remove non-contiguous and territories
  filter(!(NAME %in% c("Alaska", "District of Columbia", "Hawaii", "Puerto Rico")))
```

Reading layer `usa' from data source  
 `/Users/acorrend/Documents/GitHub/plnt6800/coding/week\_05/shp\_map/us/usa.shp'  
 using driver `ESRI Shapefile'  
 Simple feature collection with 52 features and 9 fields



Geometry type: MULTIPOLYGON  
Dimension: XY  
Bounding box: xmin: -179.1473 ymin: 17.88481 xmax: 179.7785 ymax: 71.35256  
Geodetic CRS: NAD83

```
can_shp <- st_read("shp_map/can/canada.shp")
```

Reading layer `canada' from data source  
`/Users/acorrend/Documents/GitHub/plnt6800/coding/week\_05/shp\_map/can/canada.shp'  
using driver `ESRI Shapefile'  
Simple feature collection with 13 features and 6 fields  
Geometry type: MULTIPOLYGON  
Dimension: XY  
Bounding box: xmin: -141.0181 ymin: 41.67695 xmax: -52.5823 ymax: 89.99943  
Geodetic CRS: NAD83

### 4.3 Create objects for maps

```
# Create list of selected provinces  
selected_provinces <- c("Ontario", "Manitoba", "Quebec")  
  
# Define coordinates for Ontario cities  
ontario_cities <- data.frame(  
  city = c("Toronto", "Ottawa", "Hamilton", "London", "Kingston"),  
  lon = c(-79.3832, -75.6972, -79.8711, -81.2497, -76.4880),  
  lat = c(43.6511, 45.4215, 43.2557, 42.9834, 44.2312)  
)
```

### 4.4 Define function to customize plot

```
geo_plot <- function(x, y, z, title = NULL){  
  ggplot()+  
    geom_sf(data=x, fill = "white", color = "black") + # Provinces map  
    geom_sf(data=y, fill = "white", color = "black")+ # US map  
    # Adjust scales for lat and lon  
    scale_y_continuous(limits = c(41.8, 46))+  
    scale_x_continuous(limits = c(-84, -75), breaks = seq(-84,-74, by=1)) +  
    # Add cities with points
```

```

geom_point(data = z, aes(x = lon, y = lat, fill = city),
           color = "grey25", shape = 21, size = 3, alpha = 0.95) +
# Scalebar
annotation_scale(tick_height = 0.3)+
# Text Notes for names of cities
geom_text_repel(data = z,
               aes(x=lon, y=lat, label = city), size = 3)+
# Name of PROVINCE
annotate("text", x = -78, y = 45, label = "ONTARIO",
        size = 4, fontface = "bold")+
# Name of Lakes
## Ontario
annotate("text", x = -77.8, y = 43.7, label = "Lake Ontario",
        size = 3, fontface = "italic")+
## Huron
annotate("text", x = -82.5, y = 44.5, label = "Lake \nHuron",
        size = 3, fontface = "italic")+
# Add labels
labs(title = title,
     x = "Longitude", y = "Latitude")+
# Adjust theme
theme_base()+
# reduce axis text size
theme(
  panel.background = element_rect(fill = "#bde0fe"),
  title = element_text(size = rel(.7)),
  axis.title = element_text(size = rel(.9), face = "bold"),
  axis.text = element_text(size = rel(.5))
)
}

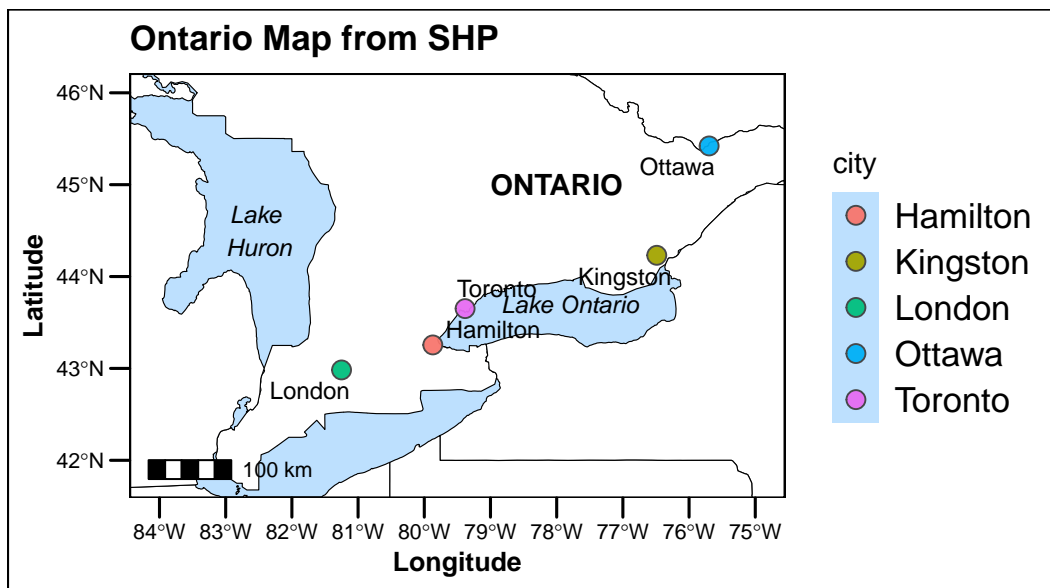
```

## 4.5 Plot

```

# Plot from function
geo_plot(x = can_shp, y = usa_shp, z = ontario_cities,
        title = "Ontario Map from SHP")

```



## 5 Working with GeoJSON Data

We can use GeoJSON files for geographic data. Here's how to load and visualize a GeoJSON file for Ontario, Canada.

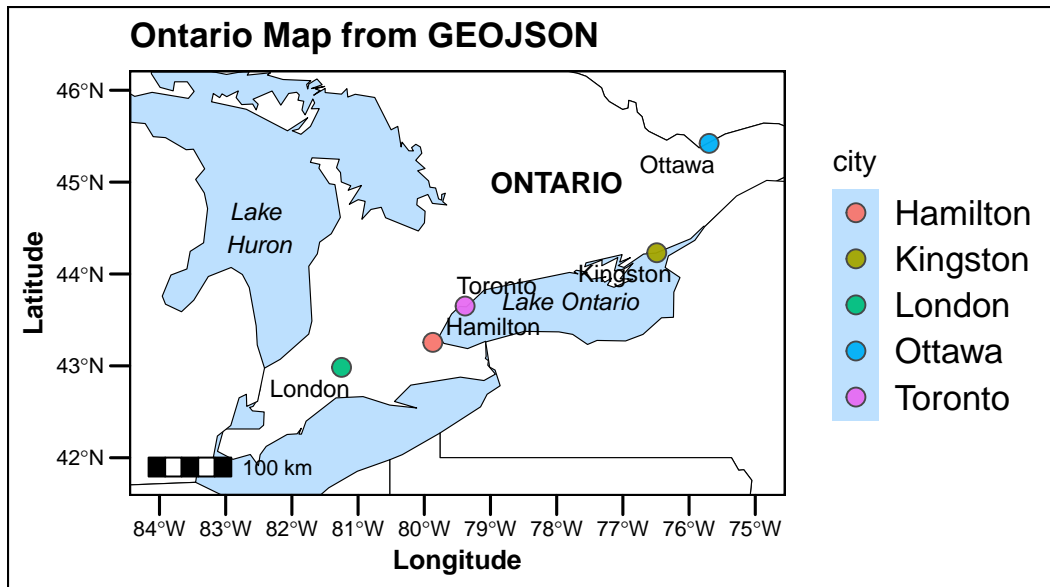
### 5.1 Loading GeoJSON Data

```
# Load Canada GeoJSON (replace with actual file path if available)
# Read geojson for Canada
can_geojson <- read_sf("geojson_maps/canada_provinces.geojson") %>%
  # dplyr::filter(name == "Ontario") %>%
  dplyr::filter(name %in% selected_provinces) %>%
  dplyr::mutate(Province = name,
               GEOID = cartodb_id) %>%
  dplyr::select(GEOID, Province, geometry)

# Read geojson for US
usa_geojson <- read_sf("geojson_maps/us-states.json")
```

## 5.2 Plot GEOJSON

```
# Plot from function
geo_plot(x = can_geojson, y = usa_geojson, z = ontario_cities,
         title = "Ontario Map from GEOJSON")
```



## 5.3 Explanation:

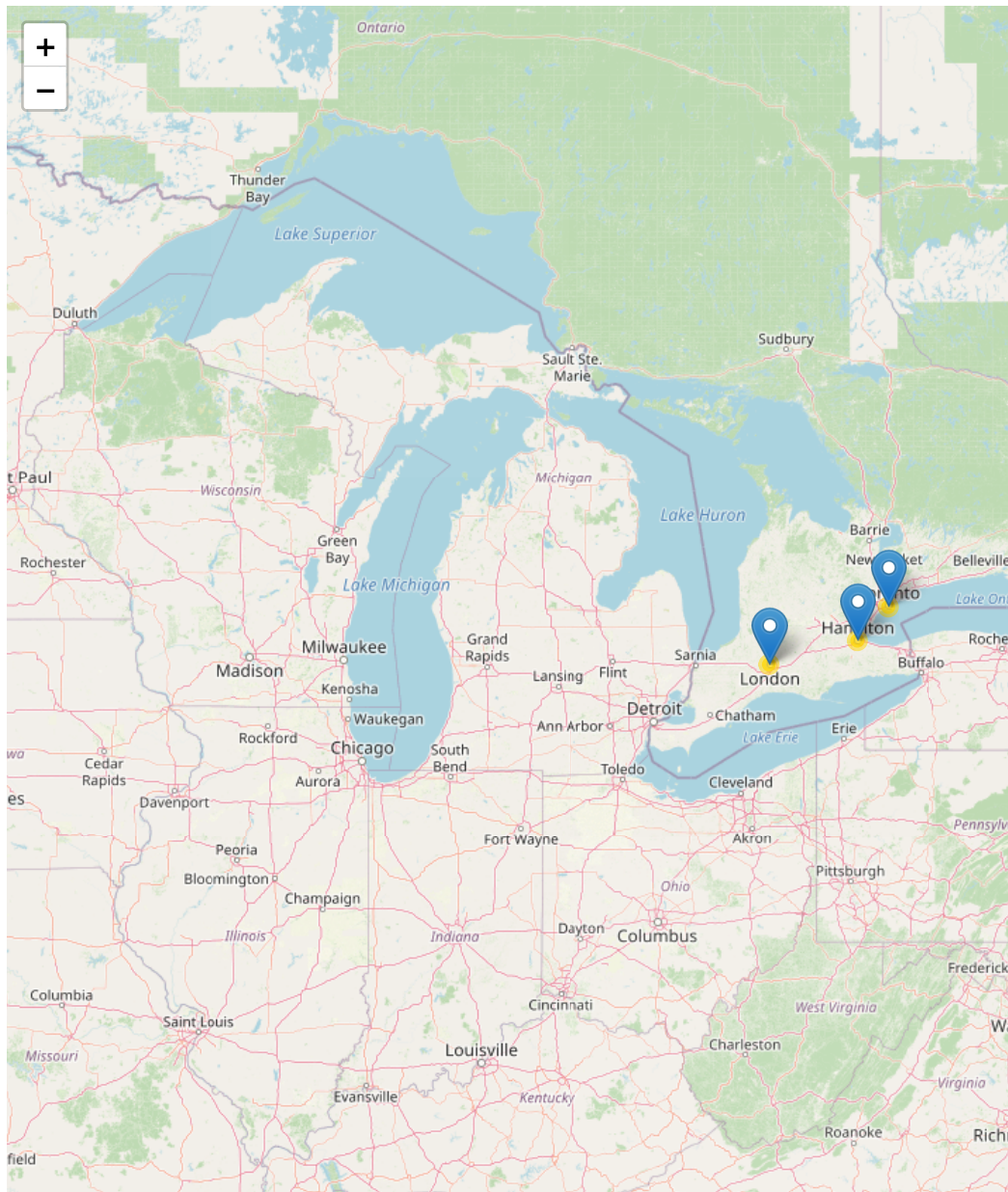
- `geojson_read()`: Reads the GeoJSON file.
- `st_as_sf()`: Converts the data into an `sf` object for plotting.
- `geom_sf()`: Plots the GeoJSON data.

## 6 Creating Interactive Maps with leaflet

leaflet allows us to create interactive maps. Let's create a map of Ontario, Canada.

## 6.1 Ontario Map with leaflet

```
# Create interactive map
ontario_cities %>%
  leaflet() %>%
    addTiles() %>%
  # Add PINS
  addMarkers(~lon, ~lat, popup = ~city) %>%
  addCircleMarkers(~lon, ~lat, popup = ~city, radius = 5, color = "gold",
    fillOpacity = 0.7) %>%
  # Configure initial view of the map
  setView(lng = -80, lat = 44, zoom = 6)
```



Leaflet | © OpenStreetMap, ODbL

## 6.2 Explanation:

- `addTiles()`: Adds the base map layer.
- `addMarkers()`: Plots city locations with popups displaying city names.
- `setView()`: Centers the map on Toronto with a specified zoom level.

## 7 Conclusion

In this lesson, you learned how to: - Create geographic maps of the US and Canada using `ggplot2` and `maps`. - Plot data points on maps with latitude and longitude coordinates. - Use shapefiles and GeoJSON for more detailed geographic visualizations with `sf`. - Customize map aesthetics for clearer and more professional presentations. - Create interactive maps using `leaflet`.

These techniques are valuable for visualizing spatial data and can be adapted for a wide range of research applications.

## 8 Additional Resources

1. [ggplot2 Documentation](#) – Official documentation for creating maps and more.
2. [sf Package Documentation](#) – Guide to handling spatial data in R.
3. [R Maps Package](#) – Reference for basic map data.
4. [Leaflet for R](#) – Documentation for interactive mapping in R.
5. [GeoJSON Data and Tools](#) – Create and explore GeoJSON data.
6. [R Spatial Data Science](#) – Tutorials and resources for spatial data analysis.
7. [R Graph Gallery - Maps](#) – Examples of different map types using R.

Experiment with different datasets and explore additional map customizations to further enhance your visualizations!