

## Question2

2024-04-06

```
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
```

```
library(lubridate)
```

```
##  
## Attaching package: 'lubridate'  
  
## The following objects are masked from 'package:base':  
##  
##   date, intersect, setdiff, union
```

```
library(ggplot2)  
library(tidyr)
```

```
# Read the CSV file  
trashwheel_data <- read.csv("data/trashwheel.csv")
```

To delve deeper into the analysis of waste collection efficiency and effectiveness, we calculate the total weight and volume of waste collected within a year. This step is crucial for understanding the scale of waste management efforts and their year-on-year progression.

- **New variables:** TotalWeight and TotalVolume calculated by taking sum of weight and volume within a year for each Trash Wheel.

```
# Data segmentation by Trash Wheel by Year  
trashwheel_segments <- trashwheel_data %>%  
  group_by(Name, Year) %>%  
  summarise(  
    TotalWeight = sum(Weight, na.rm = TRUE),  
    TotalVolume = sum(Volume, na.rm = TRUE)  
  )
```

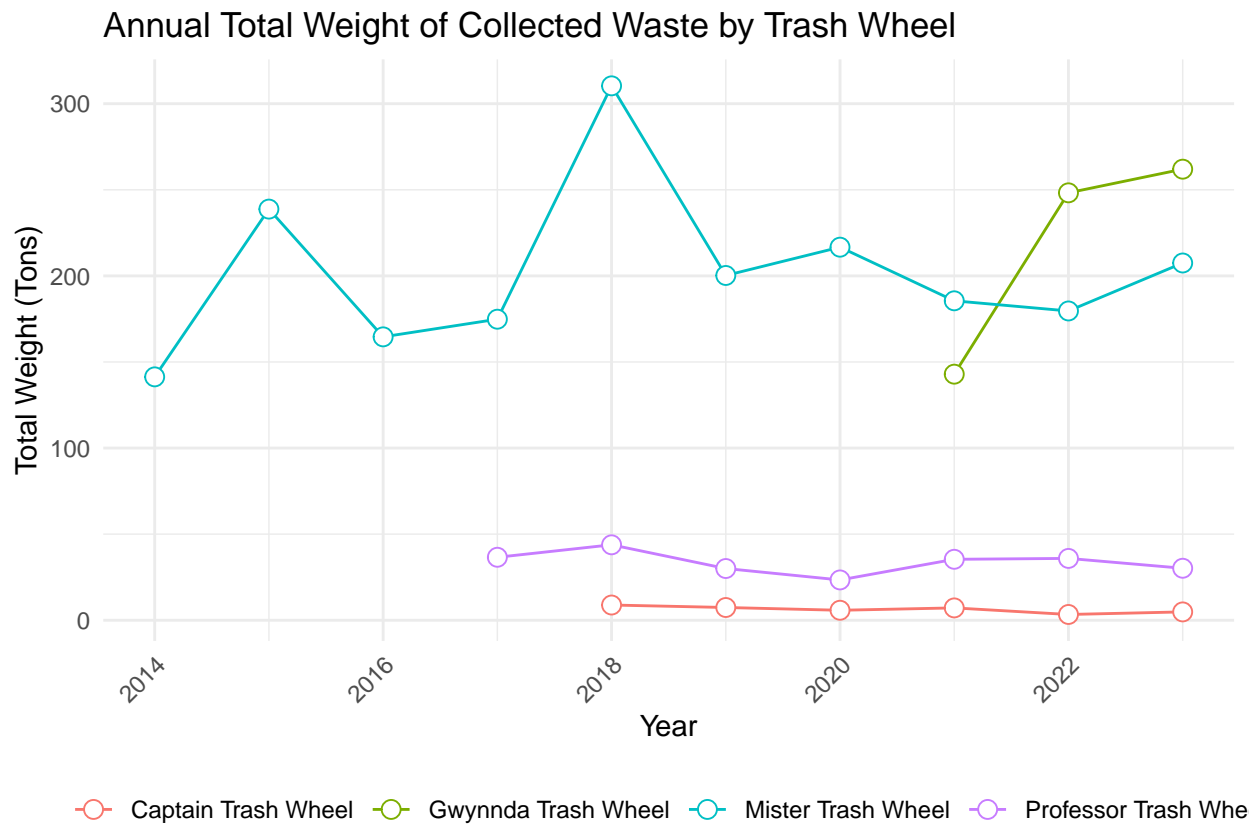
```
## 'summarise()' has grouped output by 'Name'. You can override using the
## '.groups' argument.
```

```
trashwheel_segments
```

```
## # A tibble: 26 x 4
## # Groups:   Name [4]
##   Name                Year TotalWeight TotalVolume
##   <chr>              <int>      <dbl>      <int>
## 1 Captain Trash Wheel 2018         8.83         58
## 2 Captain Trash Wheel 2019         7.39         47
## 3 Captain Trash Wheel 2020         5.79         56
## 4 Captain Trash Wheel 2021         7.16         60
## 5 Captain Trash Wheel 2022         3.34         30
## 6 Captain Trash Wheel 2023         4.84         40
## 7 Gwynnda Trash Wheel 2021        143.         735
## 8 Gwynnda Trash Wheel 2022        248.        1259
## 9 Gwynnda Trash Wheel 2023        262.        1285
## 10 Mister Trash Wheel 2014        141.         669
## # i 16 more rows
```

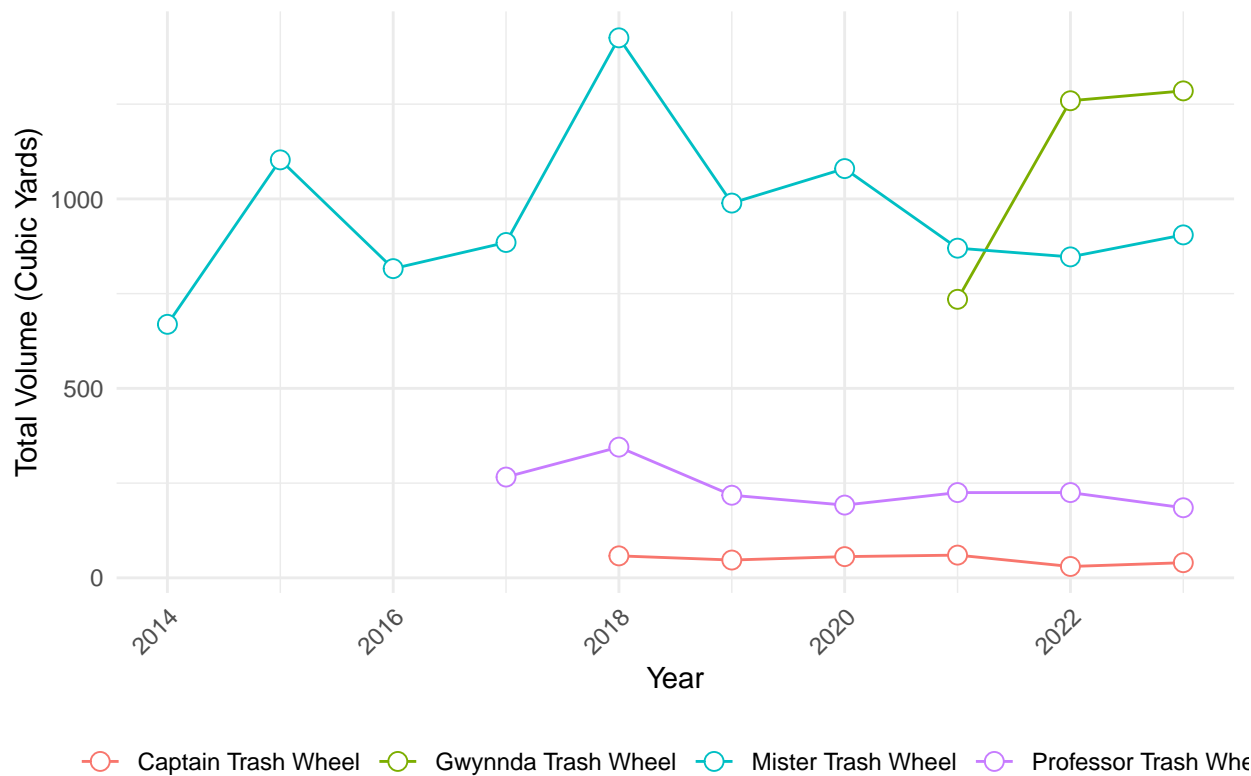
Now we plot the line graph to visualize the performance in terms of TotalWeight and TotalVolume of trash wheel over years

```
# Time-Series Analysis: Performance of each Trash Wheel over time
ggplot(trashwheel_segments, aes(x = Year, y = TotalWeight, group = Name, color = Name)) +
  geom_line() +
  geom_point(size = 3, shape = 21, fill = "white") + # Using filled points for better visibility
  theme_minimal() +
  labs(title = "Annual Total Weight of Collected Waste by Trash Wheel",
       x = "Year", y = "Total Weight (Tons)") +
  theme(legend.title = element_blank(), # Removing the legend title for clarity
        legend.position = "bottom", # Positioning legend at the bottom for easy comparison
        axis.text.x = element_text(angle = 45, hjust = 1))
```



```
ggplot(trashwheel_segments, aes(x = Year, y = TotalVolume, group = Name, color = Name)) +
  geom_line() +
  geom_point(size = 3, shape = 21, fill = "white") + # Using filled points for better visibility
  theme_minimal() +
  labs(title = "Annual Total Volume of Collected Waste by Trash Wheel",
        x = "Year", y = "Total Volume (Cubic Yards)") +
  theme(legend.title = element_blank(), # Removing the legend title for clarity
        legend.position = "bottom", # Positioning legend at the bottom for easy comparison
        axis.text.x = element_text(angle = 45, hjust = 1))
```

### Annual Total Volume of Collected Waste by Trash Wheel



Now, in order to plot a line graph to illustrate the performance of each Trash Wheel over time, highlighting trends and year-on-year changes in waste collection, we will need to calculate the rate of change in both weight and volume.

- **New Variables:** Yearly Performance Growth Rate, calculated as the percentage change in Weight and Volume from one year to the next, to quantify performance improvements or declines.

```
# Calculating Yearly Performance Growth Rate
trashwheel_segments <- trashwheel_segments %>%
  group_by(Name) %>%
  arrange(Year) %>%
  mutate(
    WeightGrowthRate = (TotalWeight / lag(TotalWeight) - 1) * 100, # Growth weight rate
    VolumeGrowthRate = (TotalVolume / lag(TotalVolume) - 1) * 100 # Growth volume rate
  ) %>%
  replace_na(list(WeightGrowthRate = 0, VolumeGrowthRate = 0)) %>% # means that at the time when a tra
  arrange(desc(WeightGrowthRate), desc(VolumeGrowthRate))
trashwheel_segments
```

```
## # A tibble: 26 x 6
## # Groups:   Name [4]
##   Name      Year TotalWeight TotalVolume WeightGrowthRate VolumeGrowthRate
##   <chr>    <int>      <dbl>      <int>          <dbl>          <dbl>
## 1 Mister Trash~ 2018        310.        1425           77.5           61.0
## 2 Gwynnda Tras~ 2022        248.        1259           73.7           71.3
## 3 Mister Trash~ 2015        239.        1103           68.9           64.9
## 4 Professor Tr~ 2021         35.4         225           51.2           17.2
```

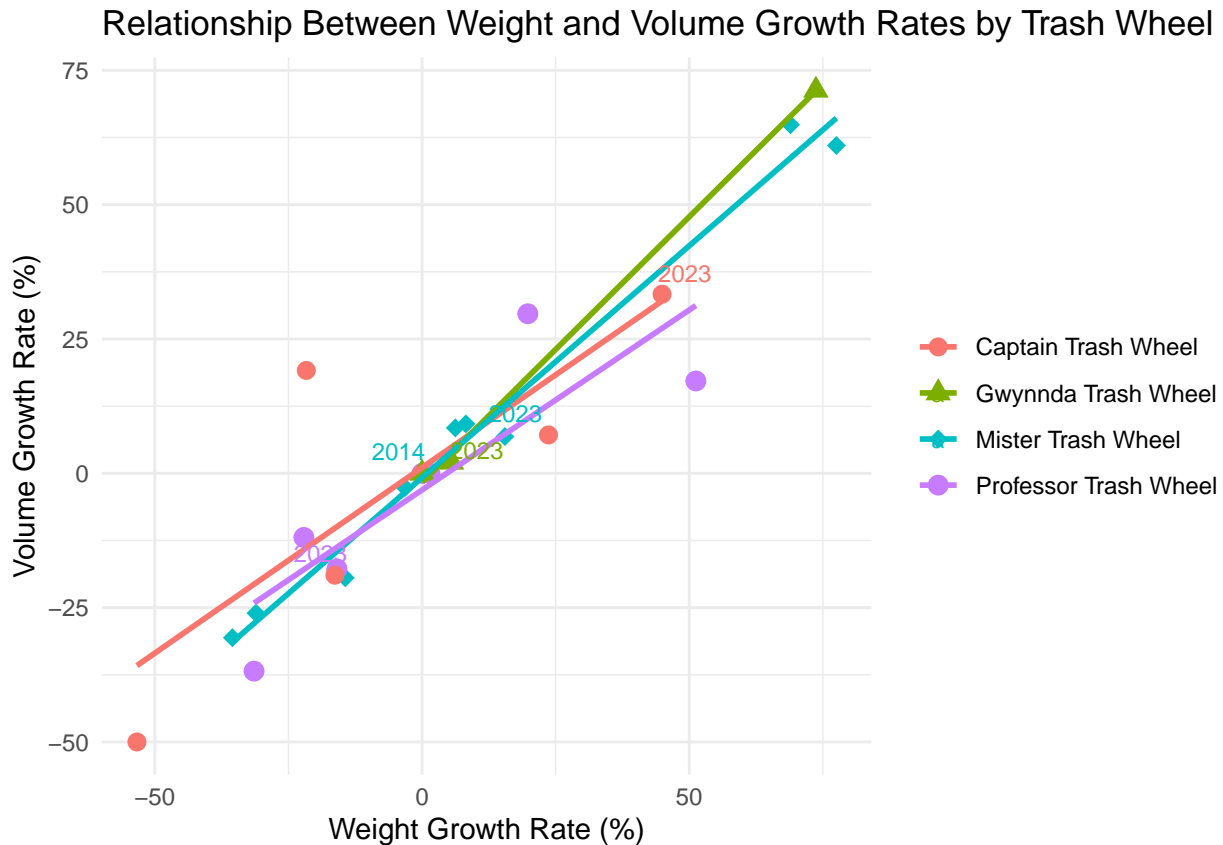
```
## 5 Captain Tras~ 2023      4.84      40      44.9      33.3
## 6 Captain Tras~ 2021      7.16      60      23.7      7.14
## 7 Professor Tr~ 2018     43.8     345     19.8     29.7
## 8 Mister Trash~ 2023    207.     905     15.5     6.85
## 9 Mister Trash~ 2020    217.    1080     8.21     9.20
## 10 Mister Trash~ 2017    175.     885     6.23     8.46
## # i 16 more rows
```

```
library(ggplot2)
library(dplyr)
library(ggrepel)

# Assigning unique shapes to each Trash Wheel
shapes <- c(16, 17, 18, 19) # Circle, Triangle, Square, Diamond

ggplot(trashwheel_segments, aes(x = WeightGrowthRate, y = VolumeGrowthRate, color = Name)) +
  geom_point(aes(shape = Name), size = 3) +
  geom_smooth(method = "lm", se = FALSE) +
  geom_text_repel(aes(label = if_else(Year == max(Year) | Year == min(Year), as.character(Year), "")),
    nudge_y = 0.05, size = 3,
    segment.color = 'grey50') + # Add labels to first and last years for clarity
  scale_shape_manual(values = shapes) + # Apply the shapes
  theme_minimal() +
  labs(title = "Relationship Between Weight and Volume Growth Rates by Trash Wheel",
    x = "Weight Growth Rate (%)", y = "Volume Growth Rate (%)") +
  theme(legend.title = element_blank())
```

```
## 'geom_smooth()' using formula = 'y ~ x'
```



The graph demonstrates a largely linear correlation between the changes in weight and volume, indicating that an increase in weight tends to correspond with an increase in volume.

Given this observation, focusing on a single attribute could simplify our analysis. Nevertheless, we will continue to examine both attributes to uncover any potential interesting phenomena that might emerge.

We plot a line graph for comparison between growth rate in both Weight and Volume as follow:

```
library(ggplot2)

# Plotting Weight Growth Rate over Time for each Trash Wheel
ggplot(trashwheel_segments, aes(x = Year, y = WeightGrowthRate, group = Name)) +
  geom_line(aes(color = Name)) +
  geom_point(aes(color = Name)) +
  geom_smooth(se = FALSE, method = "loess", color = "gray40") + # Add a smooth trend line
  facet_wrap(~Name, scales = "free_y") + # Faceting by Trash Wheel
  theme_minimal() +
  labs(title = "Weight Growth Rate Over Time by Trash Wheel",
       x = "Year", y = "Weight Growth Rate (%)") +
  theme(legend.title = element_blank(),
        axis.text.x = element_text(angle = 45, hjust = 1))

## 'geom_smooth()' using formula = 'y ~ x'

## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,
## : span too small. fewer data values than degrees of freedom.

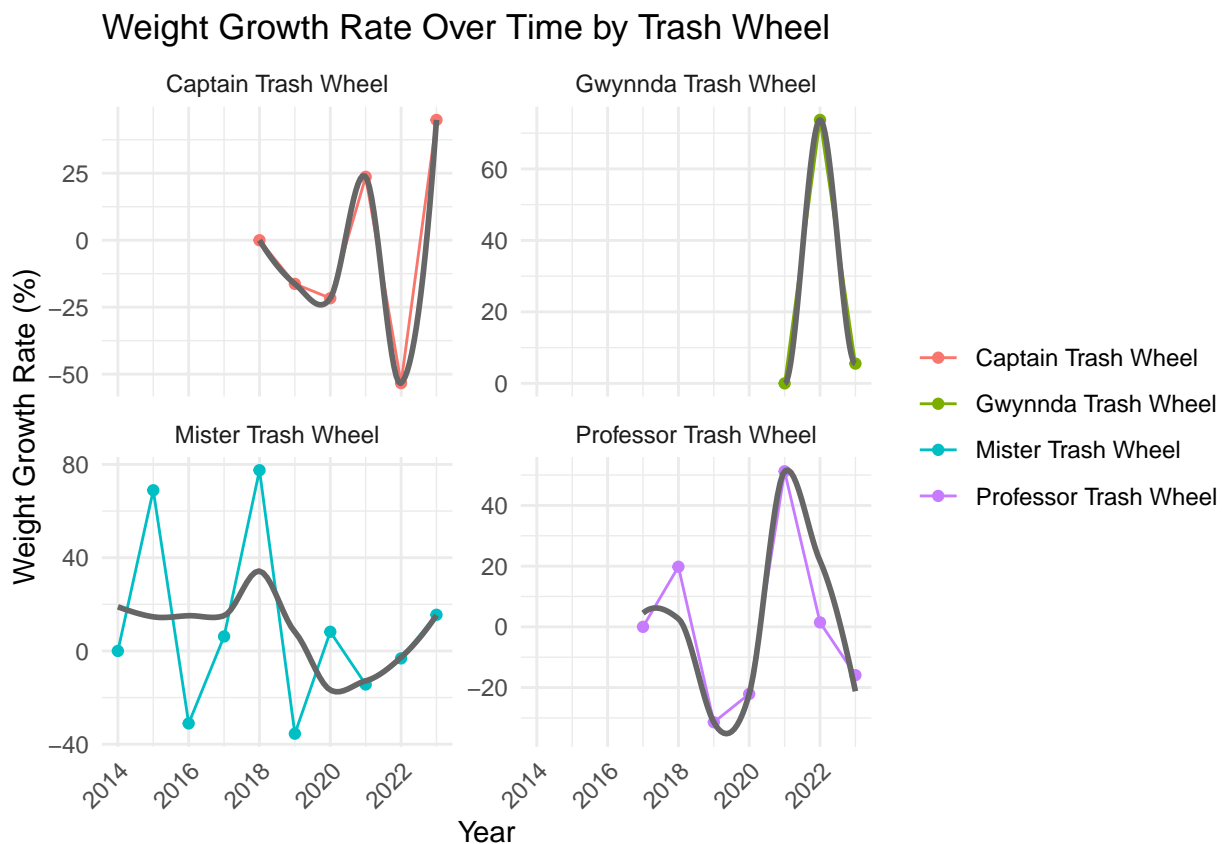
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,
```

```
## : pseudoinverse used at 2021
```

```
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,  
## : neighborhood radius 1.01
```

```
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,  
## : reciprocal condition number 0
```

```
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,  
## : There are other near singularities as well. 1.0201
```



```
# Plotting Volume Growth Rate over Time for each Trash Wheel
ggplot(trashwheel_segments, aes(x = Year, y = VolumeGrowthRate, group = Name)) +
  geom_line(aes(color = Name)) +
  geom_point(aes(color = Name)) +
  geom_smooth(se = FALSE, method = "loess", color = "gray40") + # Add a smooth trend line
  facet_wrap(~Name, scales = "free_y") + # Faceting by Trash Wheel
  theme_minimal() +
  labs(title = "Volume Growth Rate Over Time by Trash Wheel",
       x = "Year", y = "Volume Growth Rate (%)") +
  theme(legend.title = element_blank(),
        axis.text.x = element_text(angle = 45, hjust = 1))
```

```
## 'geom_smooth()' using formula = 'y ~ x'
```

```
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,
## : span too small. fewer data values than degrees of freedom.

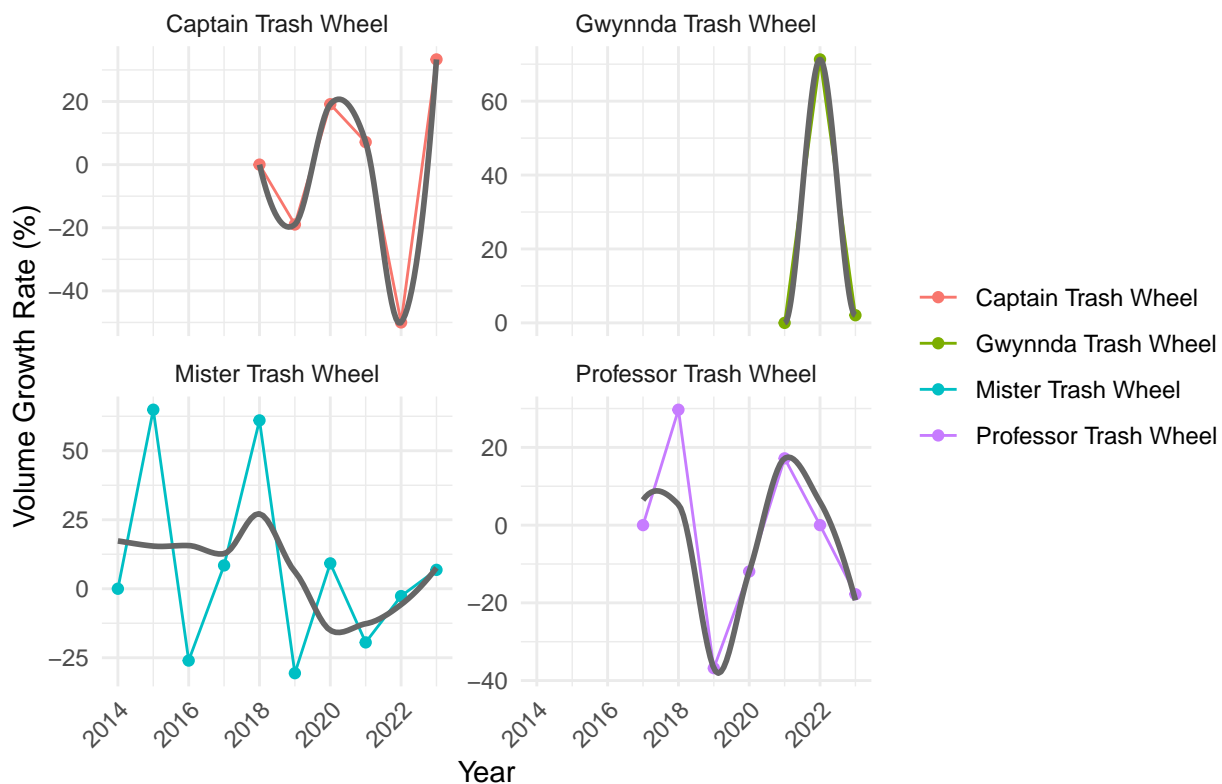
## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,
## : pseudoinverse used at 2021

## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,
## : neighborhood radius 1.01

## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,
## : reciprocal condition number 0

## Warning in simpleLoess(y, x, w, span, degree = degree, parametric = parametric,
## : There are other near singularities as well. 1.0201
```

## Volume Growth Rate Over Time by Trash Wheel



```
library(scales)
```

```
# Filter data for the most recent year
latest_year <- max(trashwheel_data$Year)
latest_year_data <- trashwheel_data %>%
  filter(Year == latest_year)
```

```
# Melt the data to long format for ggplot
composition_data_long <- latest_year_data %>%
  select(Name, PlasticBottles, Polystyrene, CigaretteButts, GlassBottles, PlasticBags, Wrappers, Sports)
```



```
gather(key = "TrashType", value = "Quantity", -Name) %>%
group_by(Name, TrashType) %>%
summarise(Quantity = sum(Quantity, na.rm = TRUE)) %>%
ungroup()
```

## 'summarise()' has grouped output by 'Name'. You can override using the  
## '.groups' argument.

```
ggplot(composition_data_long, aes(x = Name, y = Quantity, fill = TrashType)) +
  geom_bar(stat = "identity", position = "stack") +
  theme_minimal() +
  theme(
    axis.text.x = element_text(angle = 45, hjust = 1),
    legend.position = "bottom"
  ) +
  labs(title = paste("Composition of Trash Collected in", latest_year),
       x = "Trash Wheel",
       y = "Total Weight Collected") +
  scale_fill_brewer(palette = "Spectral") +
  scale_y_continuous(labels = scales::comma_format(scale = 1e-3))
```

