# Assignment 1: Aidan Power, Fiona Price, and Emily Burghart

2024-09-18

## Setting up the packages and data

Loading in the packages:

```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.1     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(ggplot2)
library(here)
```

```
## here() starts at /home/guest/Hydrology/Assignment 1
```

```
library(dplyr)
```

Now, we will load in the Eno data and make separate dataframes for the median outflow, mean outflow, and volume.

```
#Eno data:
eno_outflows <- read.csv(
  file = here("./Data Raw/Eno_River_monthly_flow_data_through-2022.csv"),
  stringsAsFactors = TRUE)
#Average of median outflow:
eno_average_median <- eno_outflows %>%
  group_by(year) %>%
  summarise(avg_median_flow = mean(median_flow, na.rm = TRUE))
#Average of mean outflow:
eno_average_mean <- eno_outflows %>%
  group_by(year) %>%
  summarise(avg_mean_flow = mean(mean_flow, na.rm = TRUE))
#Average of volume:
eno_volume_mean <- eno_outflows %>%
  group_by(year) %>%
  summarise(avg_vol = mean(total_volume, na.rm = TRUE))
```

Now, we will load in the Flat data and make separate dataframes for the median outflow, mean outflow, and volume.

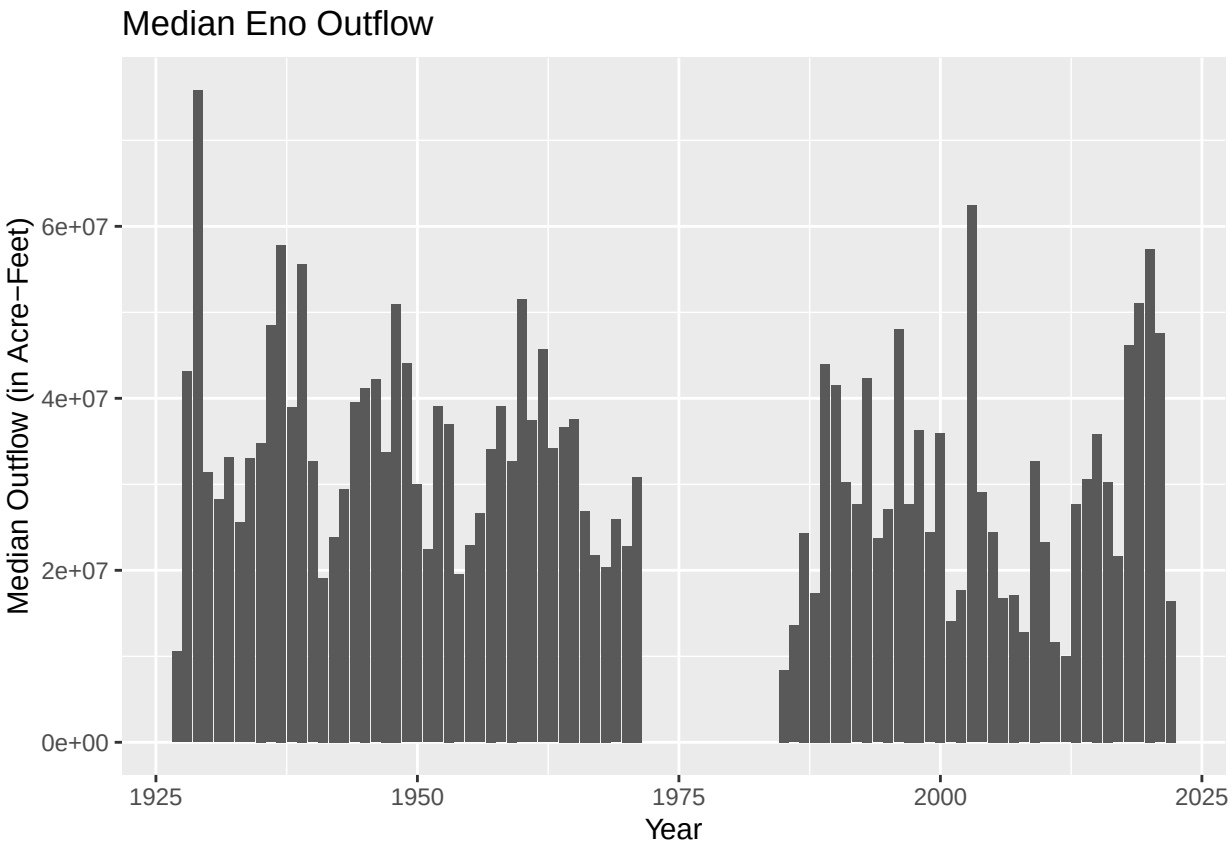
```
#Flats data:
flat_outflows <- read.csv(
  file = here("./Data Raw/Flat_River_monthly_flow_data_through-2022.csv"),
  stringsAsFactors = TRUE)
#Average of median outflow:
flat_average_median <- flat_outflows %>%
  group_by(year) %>%
  summarise(avg_median_flow = mean(median_flow, na.rm = TRUE))
#Average of mean outflow:
flat_average_mean <- flat_outflows %>%
  group_by(year) %>%
  summarise(avg_mean_flow = mean(mean_flow, na.rm = TRUE))
#Average of volume:
flat_volume_mean <- flat_outflows %>%
  group_by(year) %>%
  summarise(avg_vol = mean(total_volume, na.rm = TRUE))
```

Now, we will load in the Neuse data and make separate dataframes for the median inflow, mean inflow, and volume.

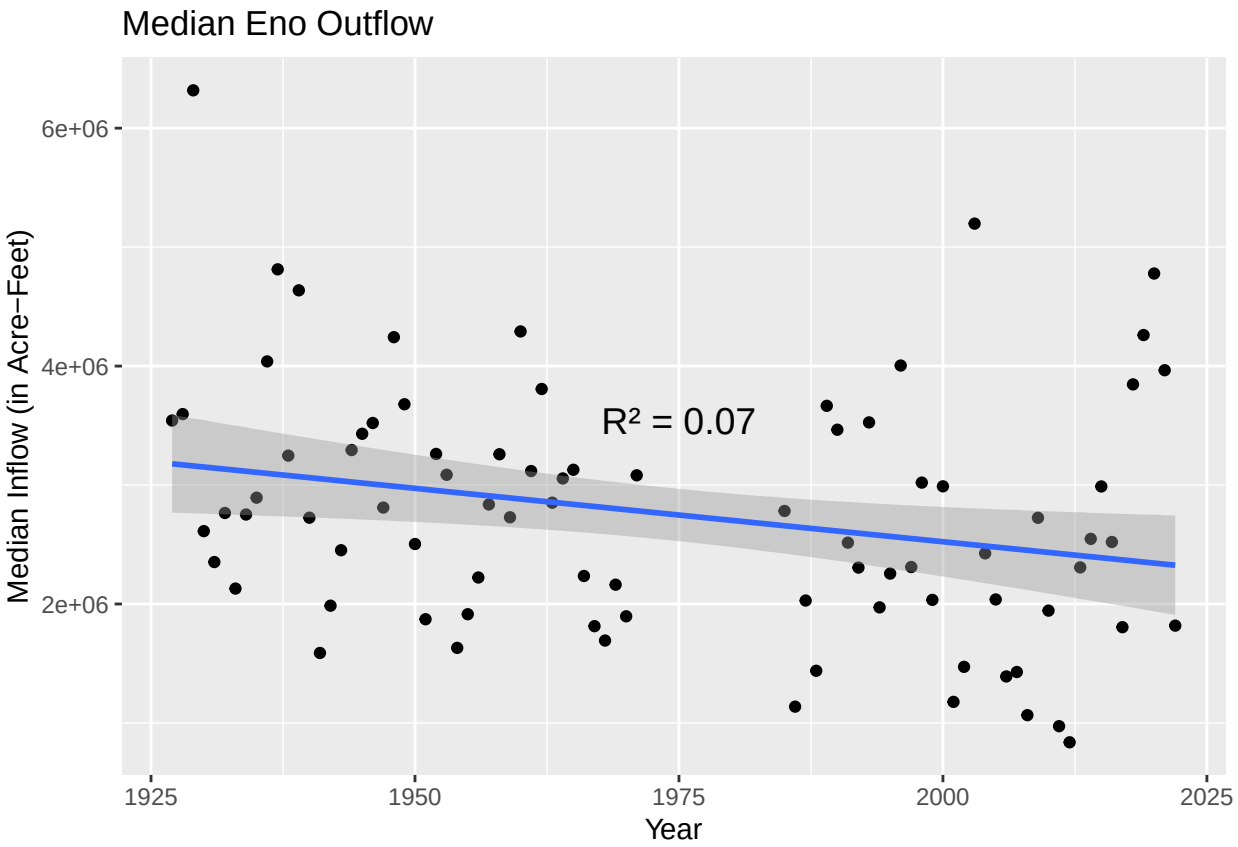
```
#Neuse data:
neuse_inflows <- read.csv(
  file = here("./Data Raw/Falls_Lake_outlet_Neuse_River_monthly_flow_data_through-2022.csv"),
  stringsAsFactors = TRUE)
#Average of median inflow:
neuse_average_median <- neuse_inflows %>%
  group_by(year) %>%
  summarise(avg_median_flow = mean(median_flow, na.rm = TRUE))
#Average of mean inflow:
neuse_average_mean <- neuse_inflows %>%
  group_by(year) %>%
  summarise(avg_mean_flow = mean(mean_flow, na.rm = TRUE))
#Average of volume:
neuse_volume_mean <- neuse_inflows %>%
  group_by(year) %>%
  summarise(avg_vol = mean(total_volume, na.rm = TRUE))
```

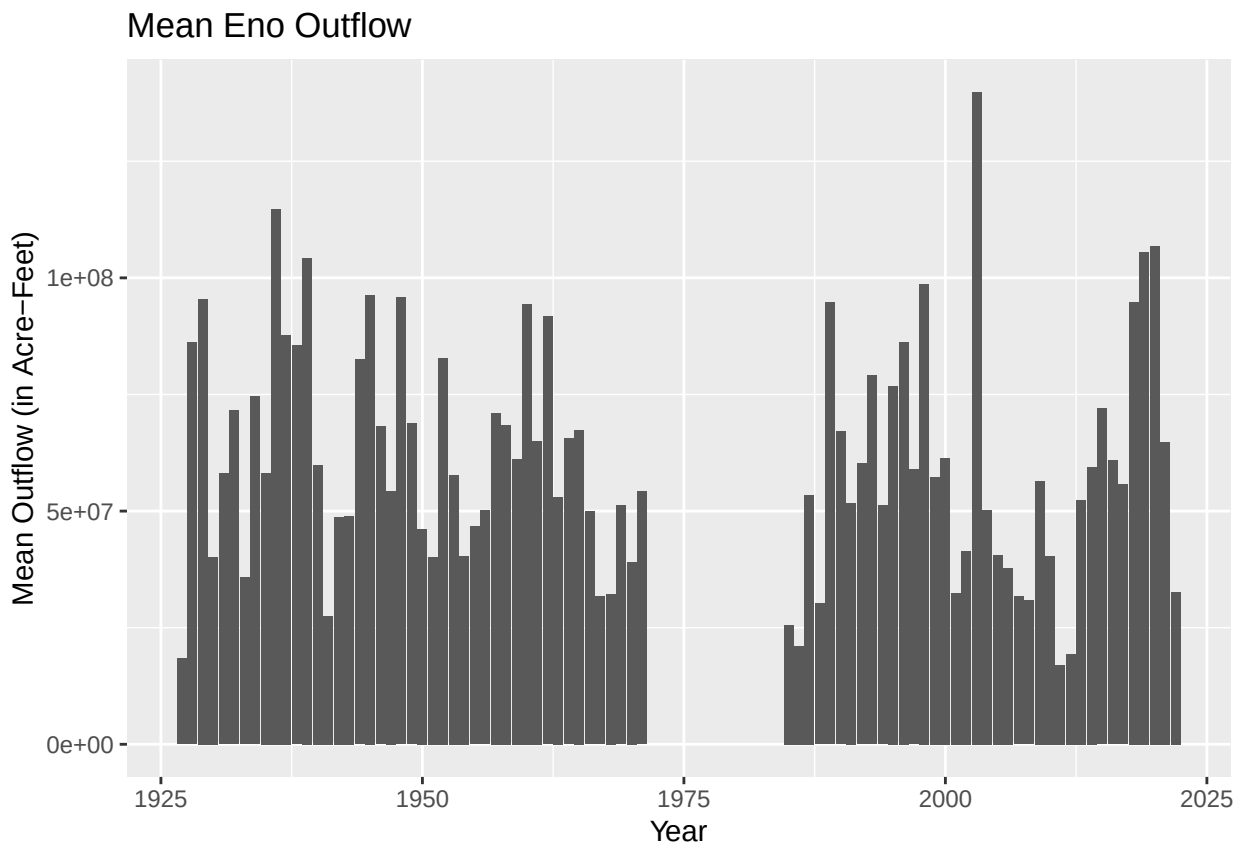
## Plots

Now, we will start making graphs. First, we will look at Eno. We will start with all years.

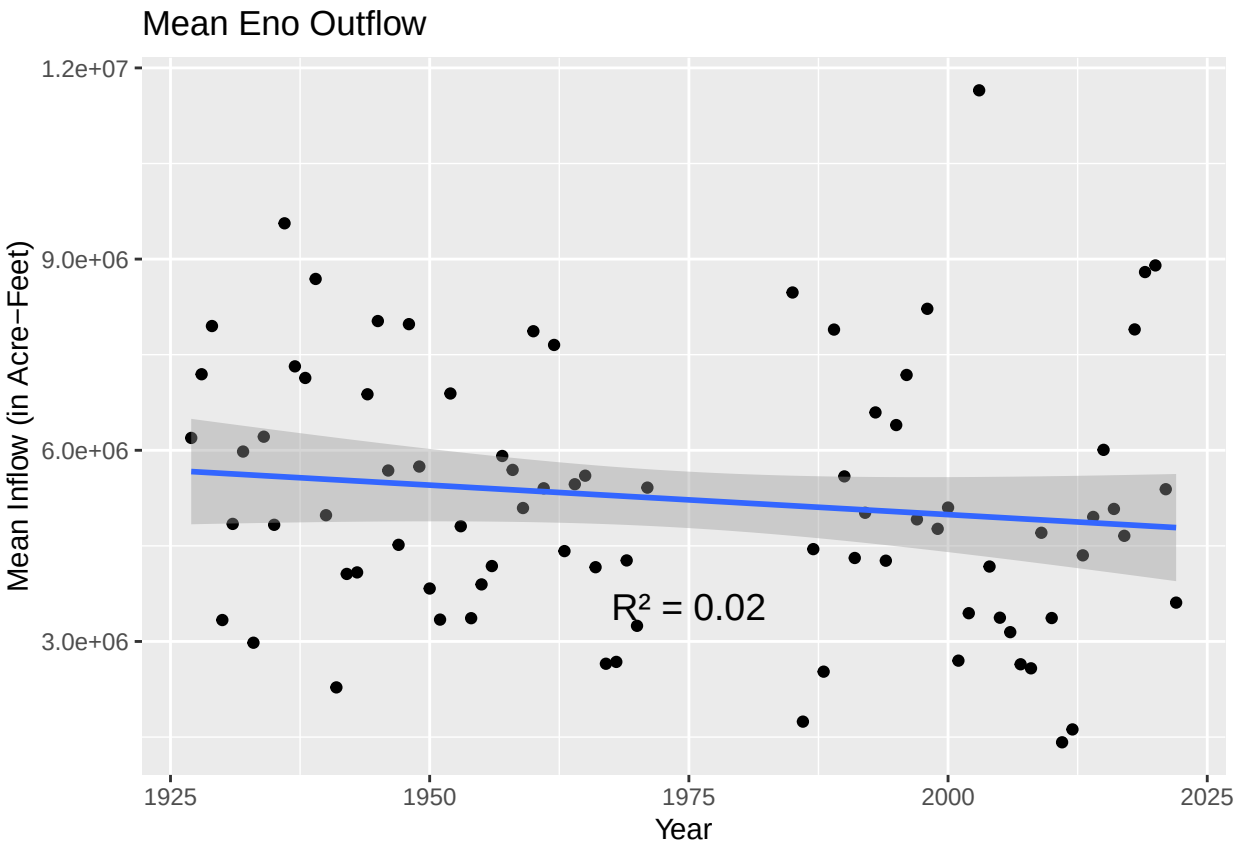


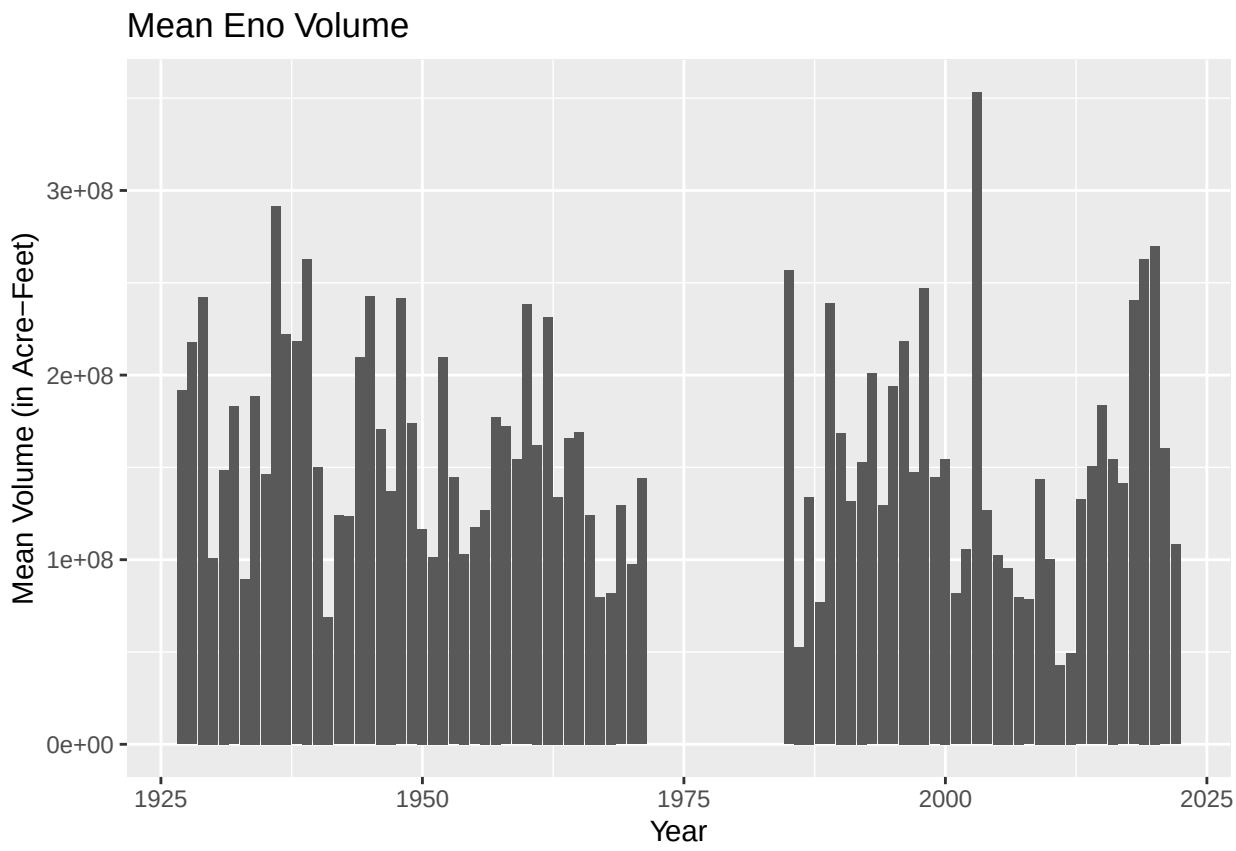

```
## `geom_smooth()` using formula = 'y ~ x'
```


Median Eno Outflow
Median Inflow (in Acre−Feet)
6e+06
4e+06
2e+06
R² = 0.07
1925
1950
1975
2000
2025
Year

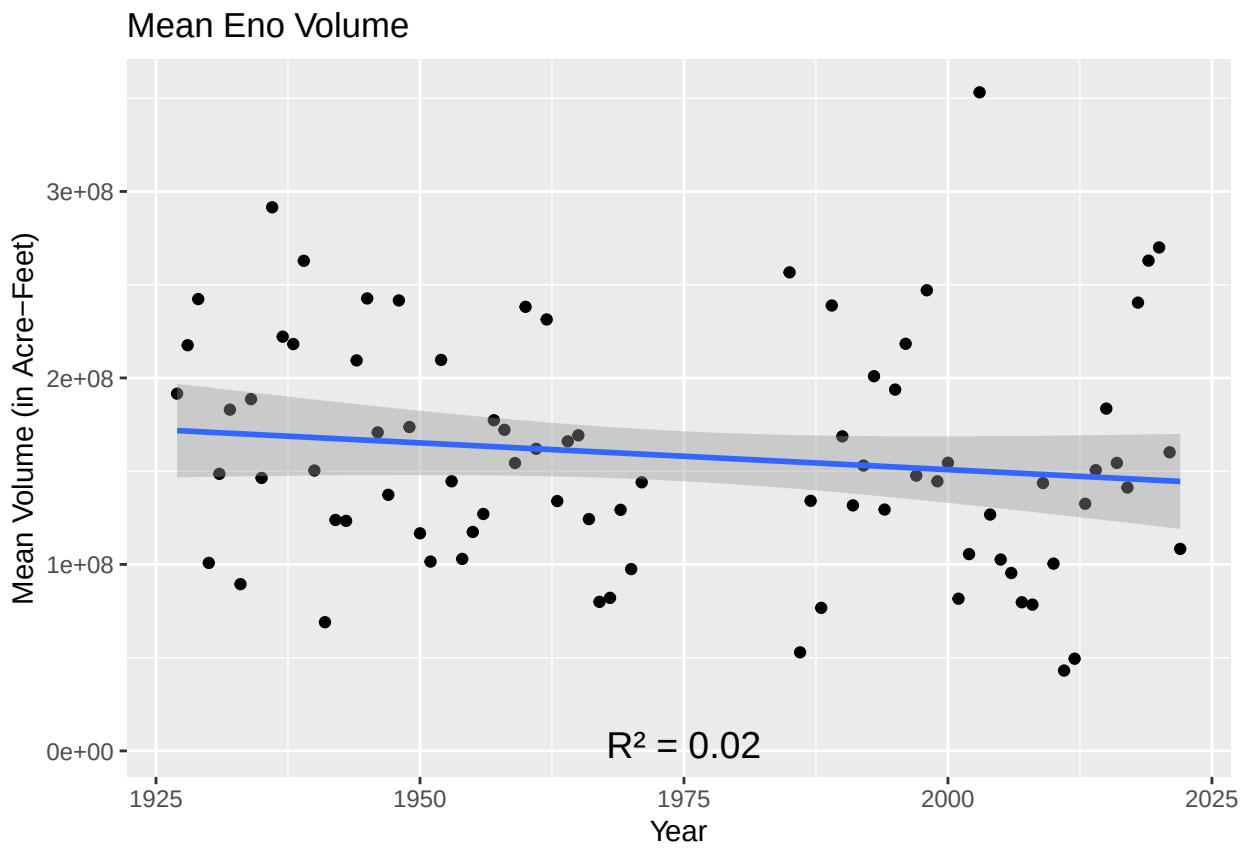



```
## `geom_smooth()` using formula = 'y ~ x'
```


Mean Eno Outflow
1.2e+07
9.0e+06
6.0e+06
3.0e+06
Mean Inflow (in Acre−Feet)
1925
1950
1975
2000
2025
Year
R² = 0.02

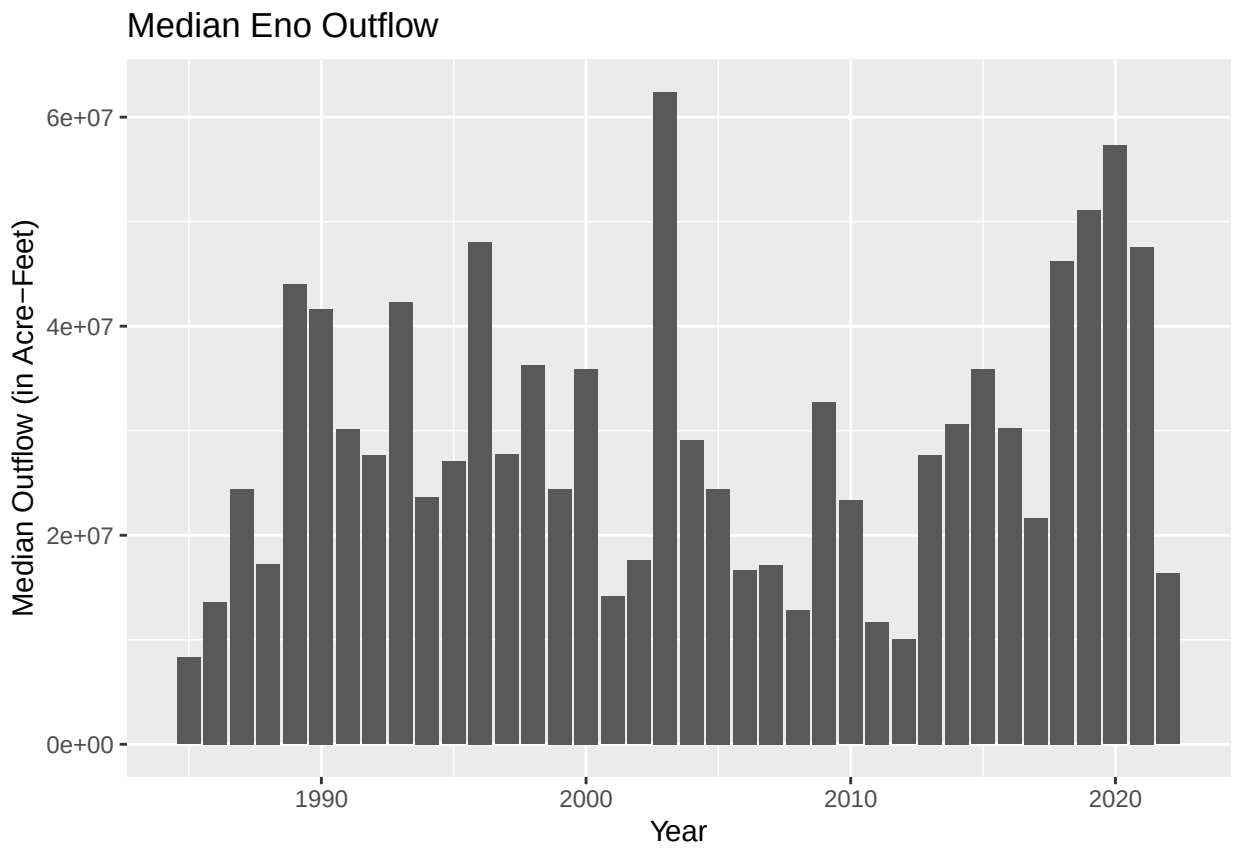



```
## `geom_smooth()` using formula = 'y ~ x'
```



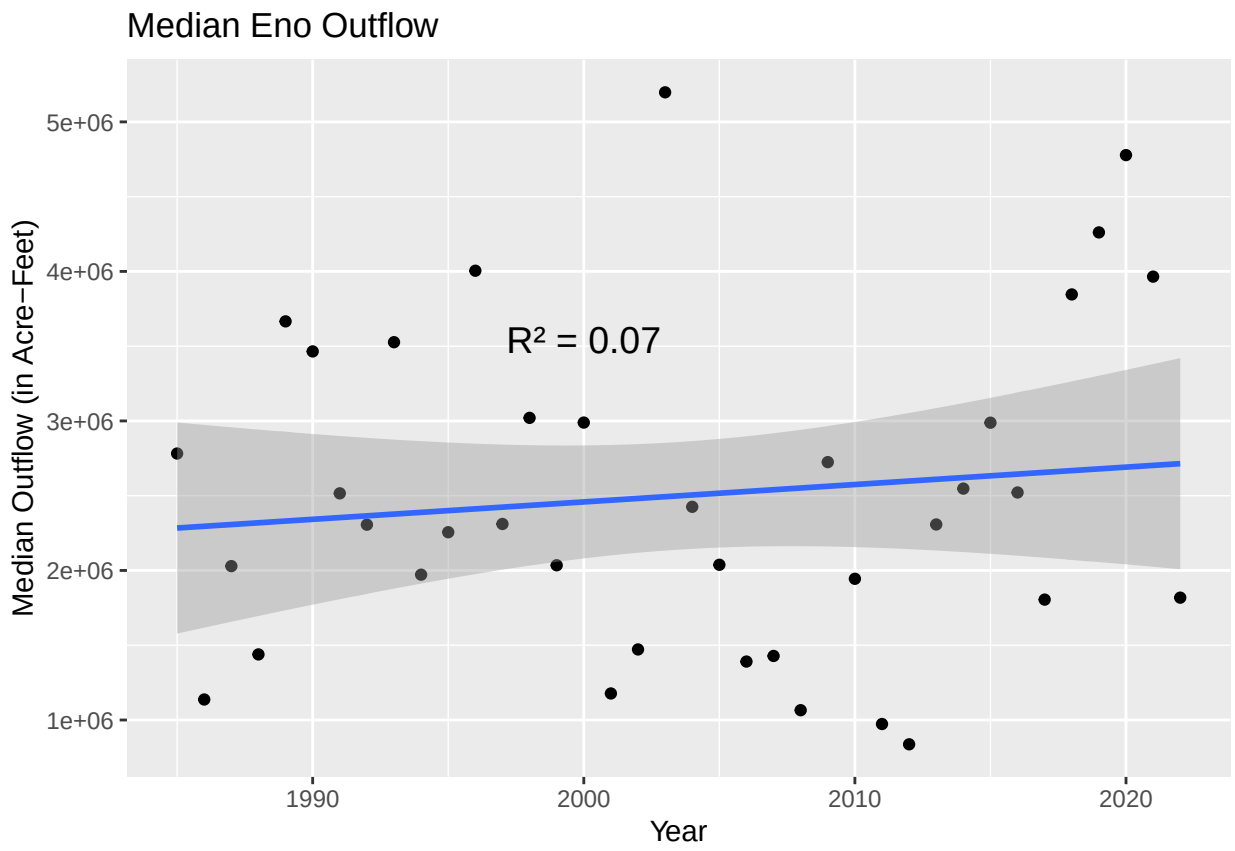

There is a gap in Eno data from 1971-1985. Now, we will look only at the post-1985 data.

```
#Filter out the data to only include 1985 and beyond.
eno_filtered <- eno_outflows %>%
  filter(year >= 1981)
#Filter out the average median outflow data to only include 1985 and beyond.
eno_avemedian_filtered <- eno_average_median %>%
  filter(year >= 1981)
#Filter out the average mean outflow data to only include 1985 and beyond.
eno_avemean_filtered <- eno_average_mean %>%
  filter(year >= 1981)
#Filter out the average volume data to only include 1985 and beyond.
eno_vol_filtered <- eno_volume_mean %>%
  filter(year >= 1981)

#Median Eno outflow
ggplot(data = (eno_filtered)) +
  geom_col(data = eno_filtered, aes(x = year, y = median_flow)) +
  labs(title = "Median Eno Outflow", x = "Year", y = "Median Outflow (in Acre-Feet)")
```

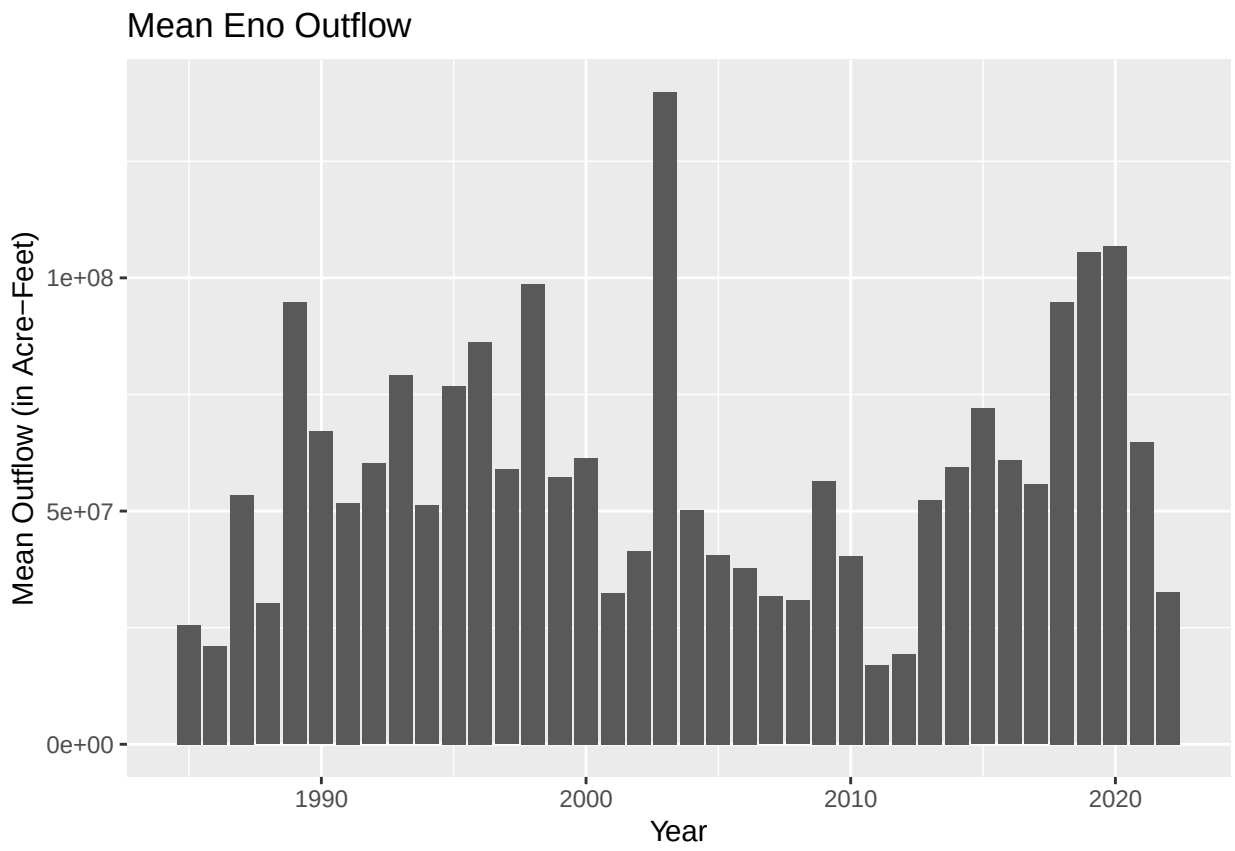



```
eno_med_model_1981 <- lm(year ~ avg_median_flow, data = eno_average_median)
r_squared_4 <- summary(eno_med_model_1981)$r.squared

ggplot(data = eno_avemedian_filtered, aes(x = year, y = avg_median_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Median Eno Outflow", x = "Year", y = "Median Outflow (in Acre-Feet)") +
  annotate("text", x = 2000, y = 3542400,
           label = paste("R² =", round(r_squared_4, 2)),
           size = 5)
```

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

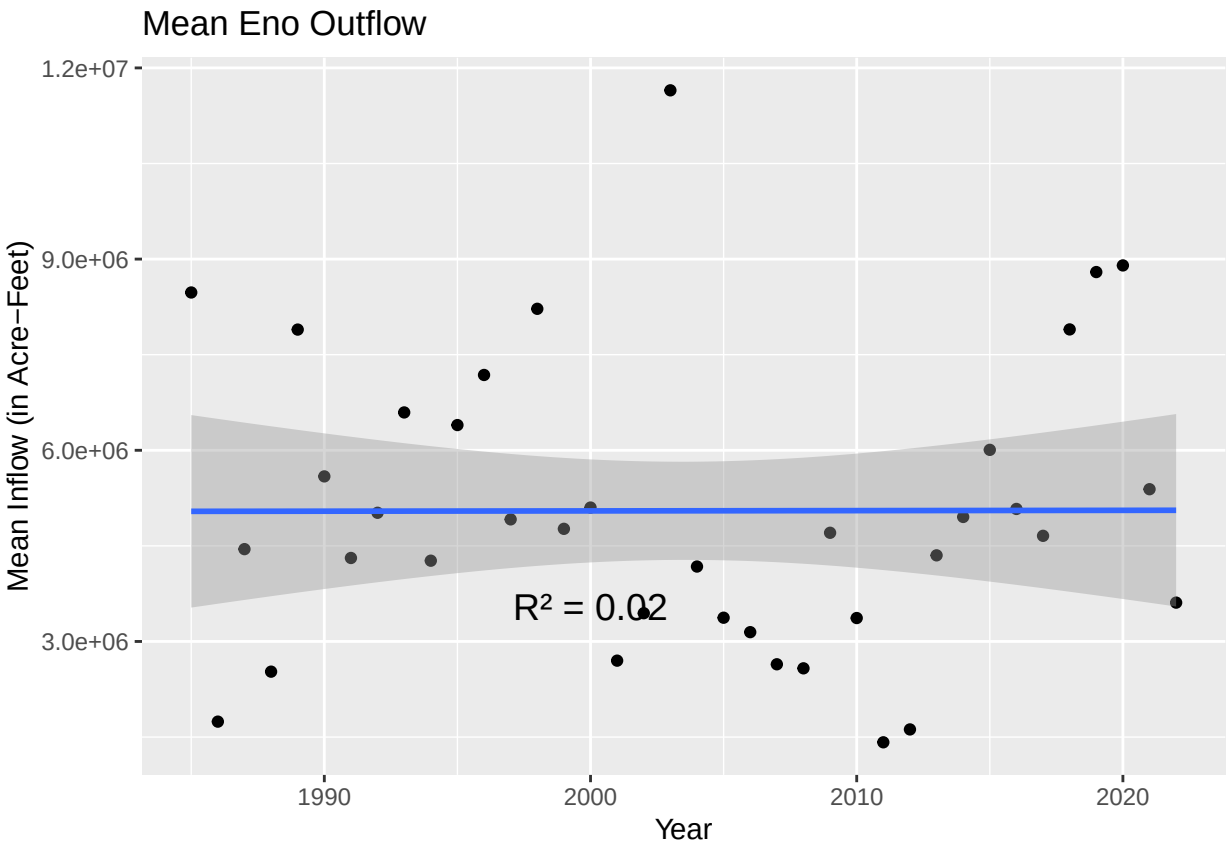



```
#Mean Eno outflow
ggplot(data = eno_filtered) +
  geom_col(data = eno_filtered, aes(x = year, y = mean_flow)) +
  labs(title = "Mean Eno Outflow", x = "Year", y = "Mean Outflow (in Acre-Feet)")
```

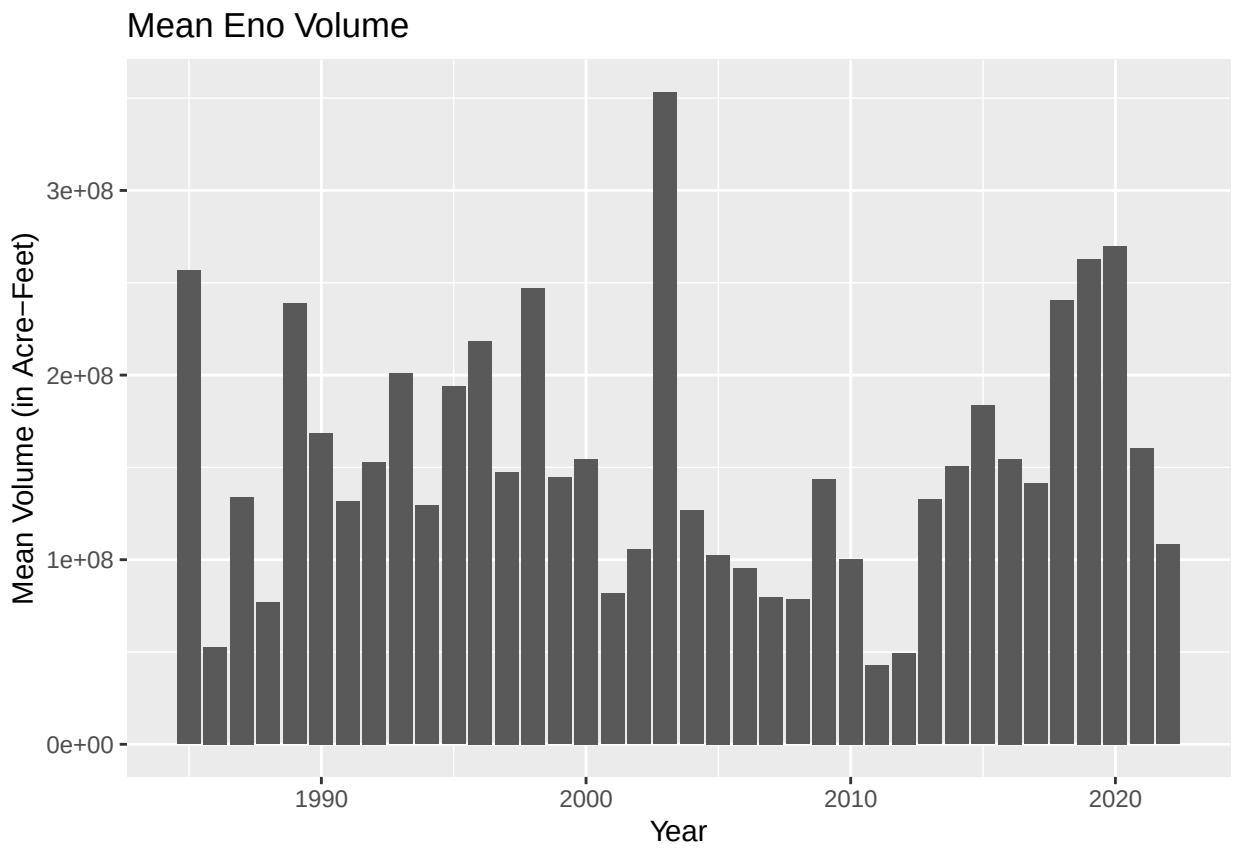



```
eno_mean_model_1981 <- lm(year ~ avg_mean_flow, data = eno_average_mean)
r_squared_5 <- summary(eno_mean_model_1981)$r.squared

ggplot(data = eno_avemean_filtered, aes(x = year, y = avg_mean_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Eno Outflow", x = "Year", y = "Mean Inflow (in Acre-Feet)") +
   annotate("text", x = 2000, y = 3542400,
            label = paste("R² =", round(r_squared_5, 2)),
            size = 5)
```

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

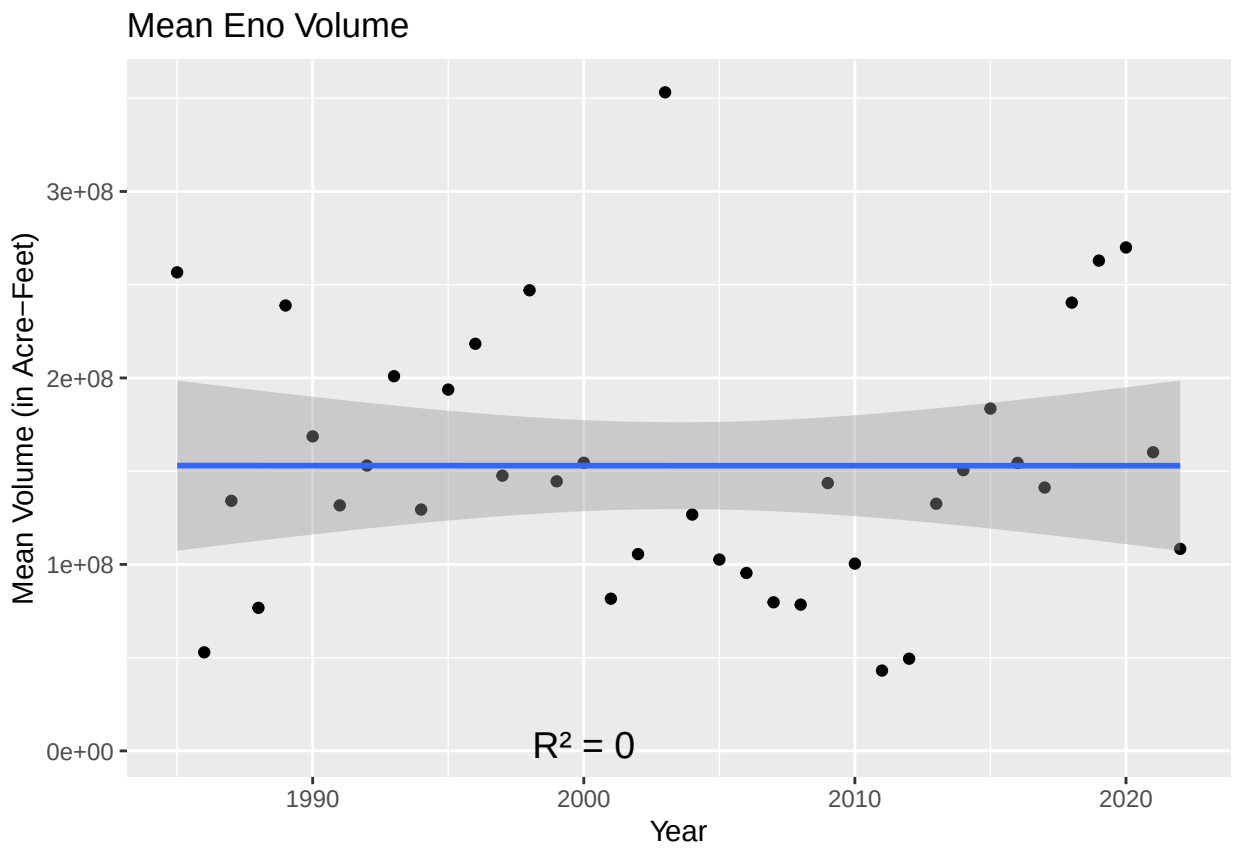



```
#Mean Eno volume
ggplot(data = eno_vol_filtered) +
  geom_col(data = eno_vol_filtered, aes(x = year, y = avg_vol)) +
  labs(title = "Mean Eno Volume", x = "Year", y = "Mean Volume (in Acre-Feet)")
```



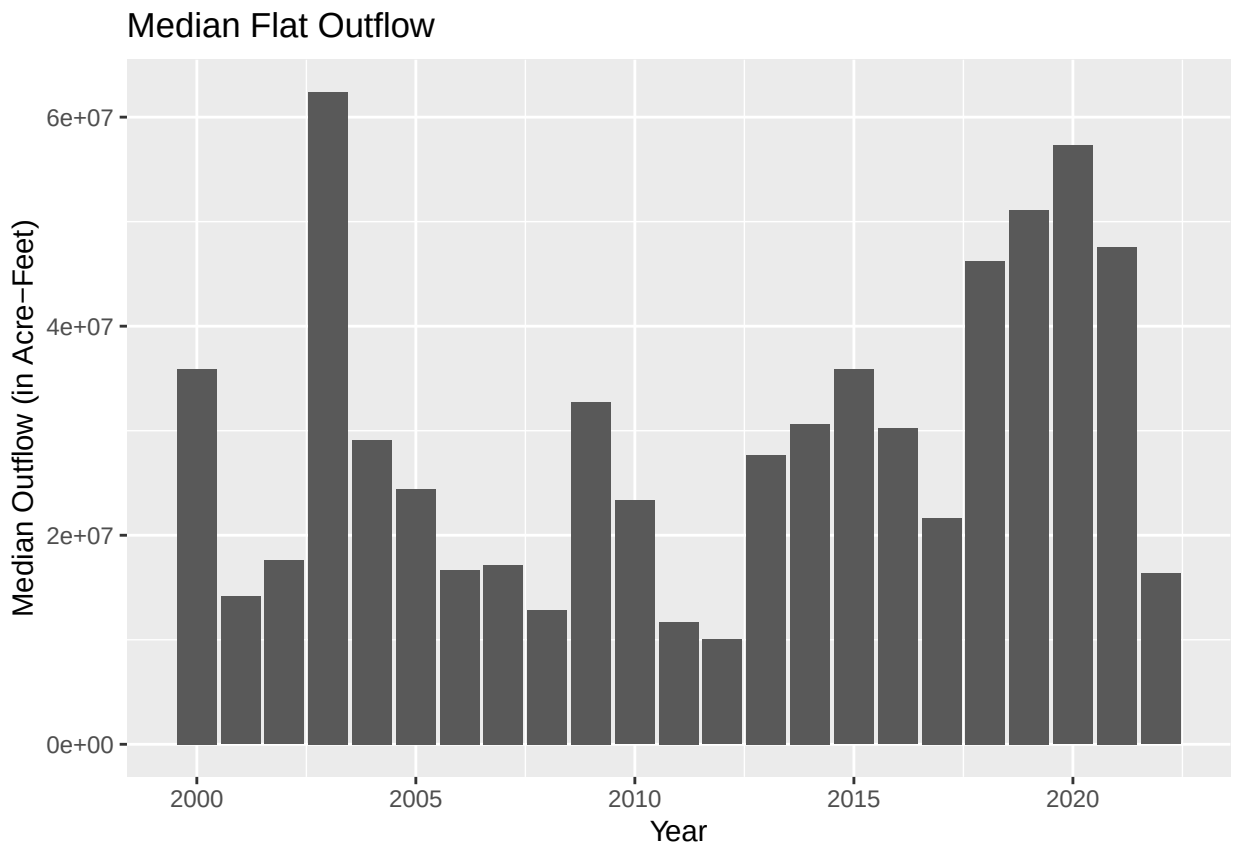

```
eno_vol_model_1981 <- lm(year ~ avg_vol, data = eno_vol_filtered)
r_squared_6 <- summary(eno_vol_model_1981)$r.squared

ggplot(data = eno_vol_filtered, aes(x = year, y = avg_vol)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Eno Volume", x = "Year", y = "Mean Volume (in Acre-Feet)") +
     annotate("text", x = 2000, y = 3542400,
           label = paste("R² =", round(r_squared_6, 2)),
           size = 5)
```

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



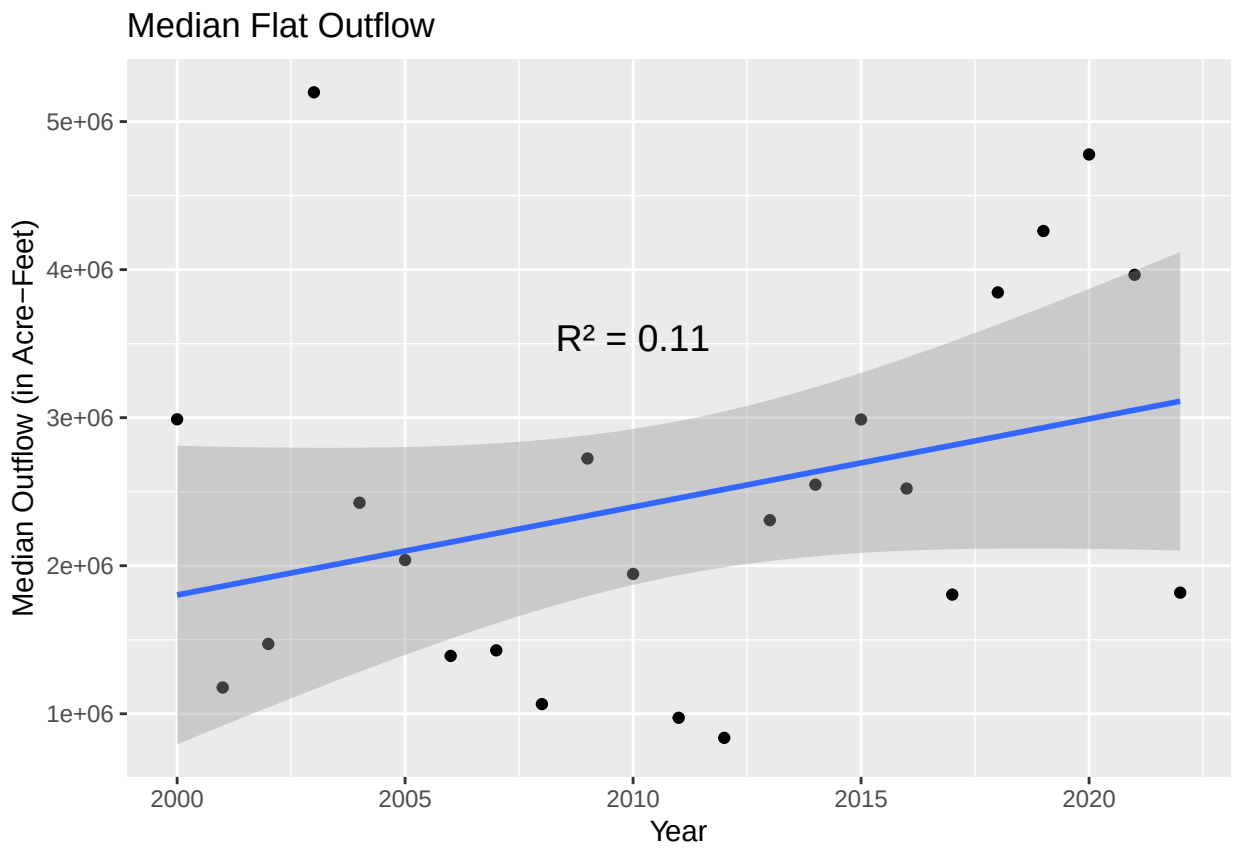

Lastly, we will look at only years 2000 and beyond to capture recent trends.

```
#Filter out the data to only include 2000 and beyond.
eno_2000 <- eno_outflows %>%
  filter(year >= 2000)
#Filter out the average median outflow data to only include 2000 and beyond.
eno_2000_median <- eno_average_median %>%
  filter(year >= 2000)
#Filter out the average mean outflow data to only include 2000 and beyond.
eno_2000_mean <- eno_average_mean %>%
  filter(year >= 2000)
#Filter out the average volume data to only include 2000 and beyond.
eno_2000_volume <- eno_volume_mean %>%
  filter(year >= 2000)

#Median Eno outflow
ggplot(data = eno_2000) +
  geom_col(data = eno_2000, aes(x = year, y = median_flow)) +
  labs(title = "Median Flat Outflow", x = "Year", y = "Median Outflow (in Acre-Feet)")
```

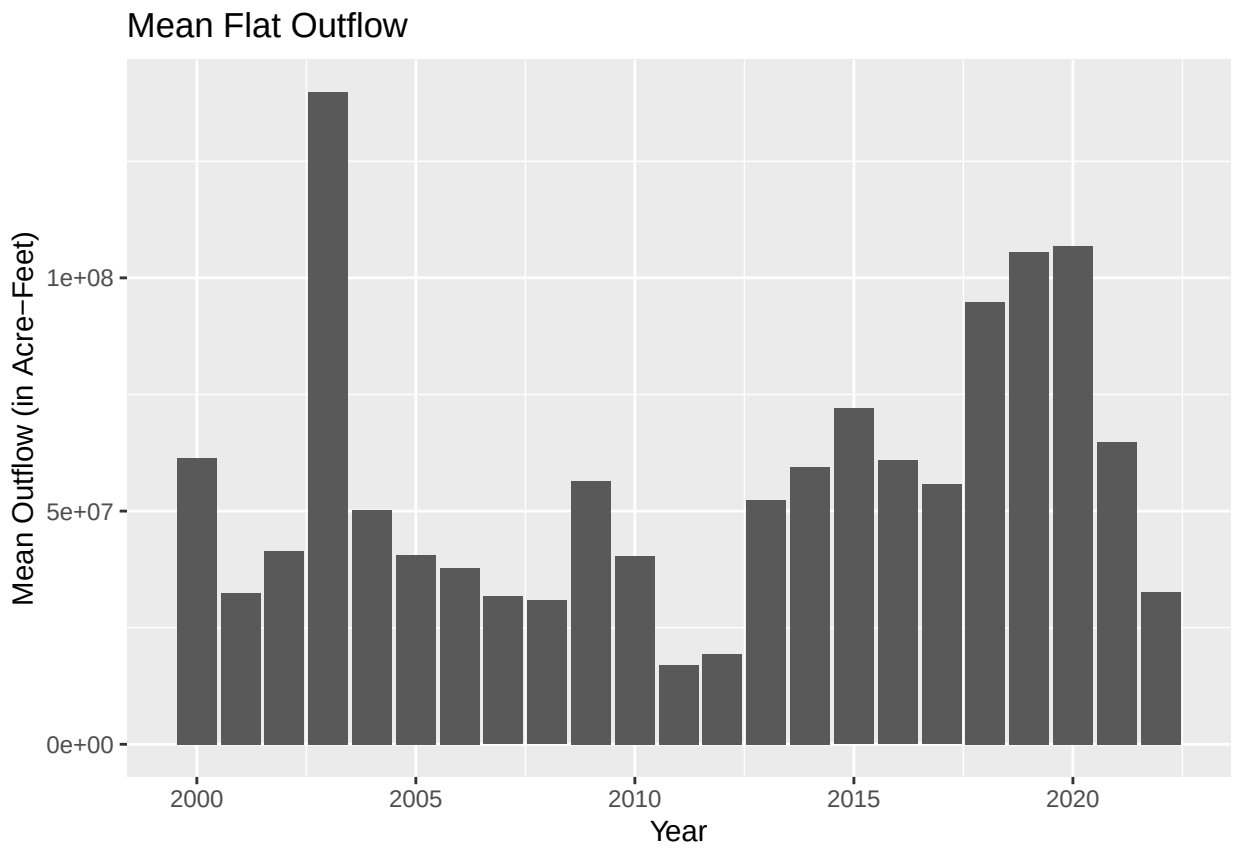



```
eno_med_model_2000 <- lm(year ~ avg_median_flow, data = eno_2000_median)
r_squared_7 <- summary(eno_med_model_2000)$r.squared

ggplot(data = eno_2000_median, aes(x = year, y = avg_median_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Median Flat Outflow", x = "Year", y = "Median Outflow (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(r_squared_7, 2)),
           size = 5)
```

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

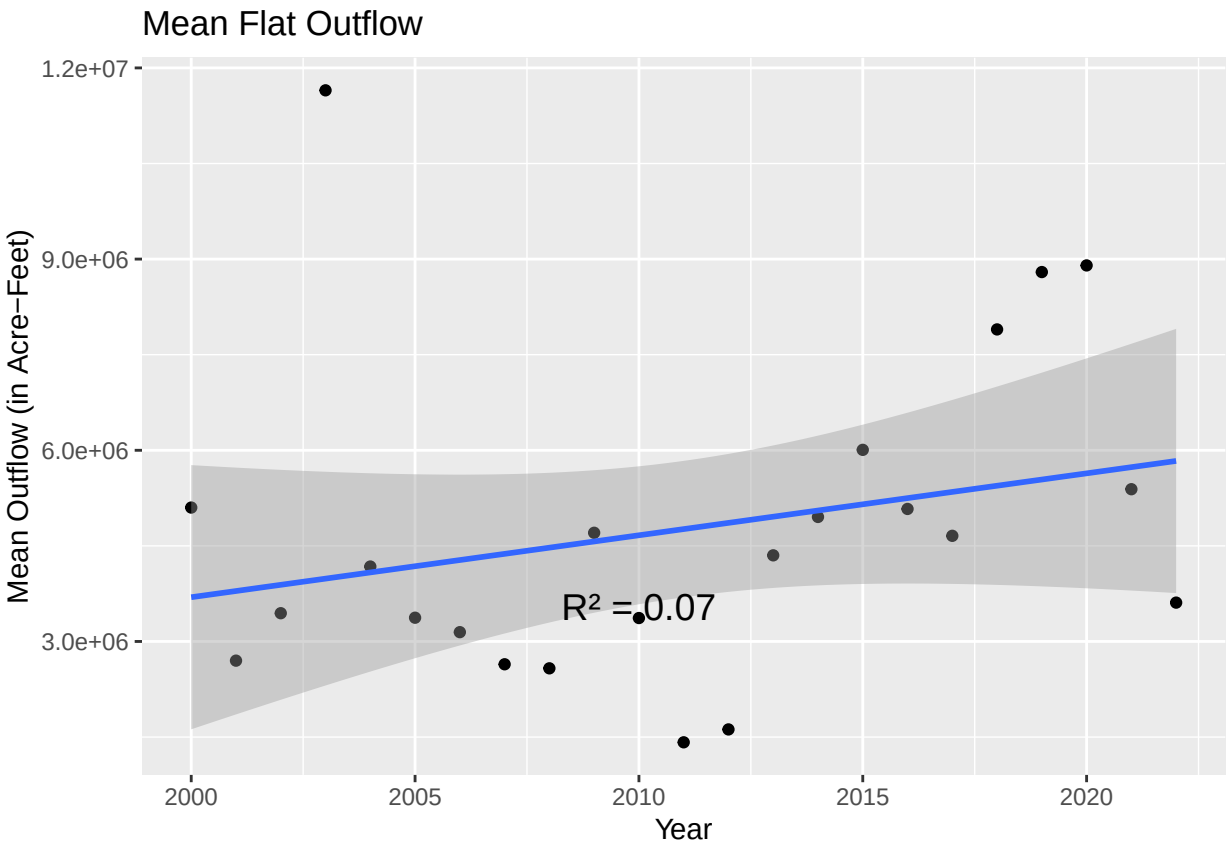



```
#Mean Eno outflow
ggplot(data = eno_2000) +
  geom_col(data = eno_2000, aes(x = year, y = mean_flow)) +
  labs(title = "Mean Flat Outflow", x = "Year", y = "Mean Outflow (in Acre-Feet)")
```

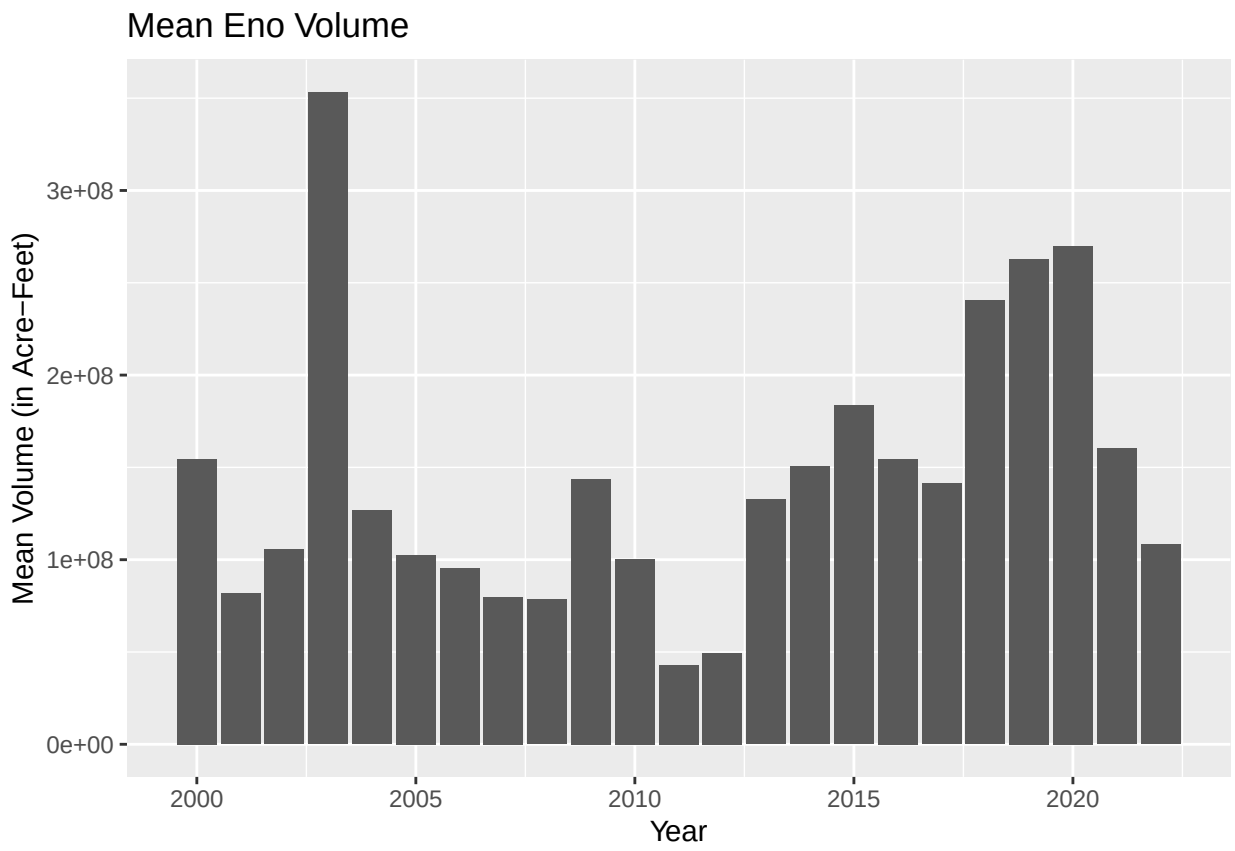



```
eno_mean_model_2000 <- lm(year ~ avg_mean_flow, data = eno_2000_mean)
r_squared_8 <- summary(eno_mean_model_2000)$r.squared

ggplot(data = eno_2000_mean, aes(x = year, y = avg_mean_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Flat Outflow", x = "Year", y = "Mean Outflow (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(r_squared_8, 2)),
           size = 5)
```

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

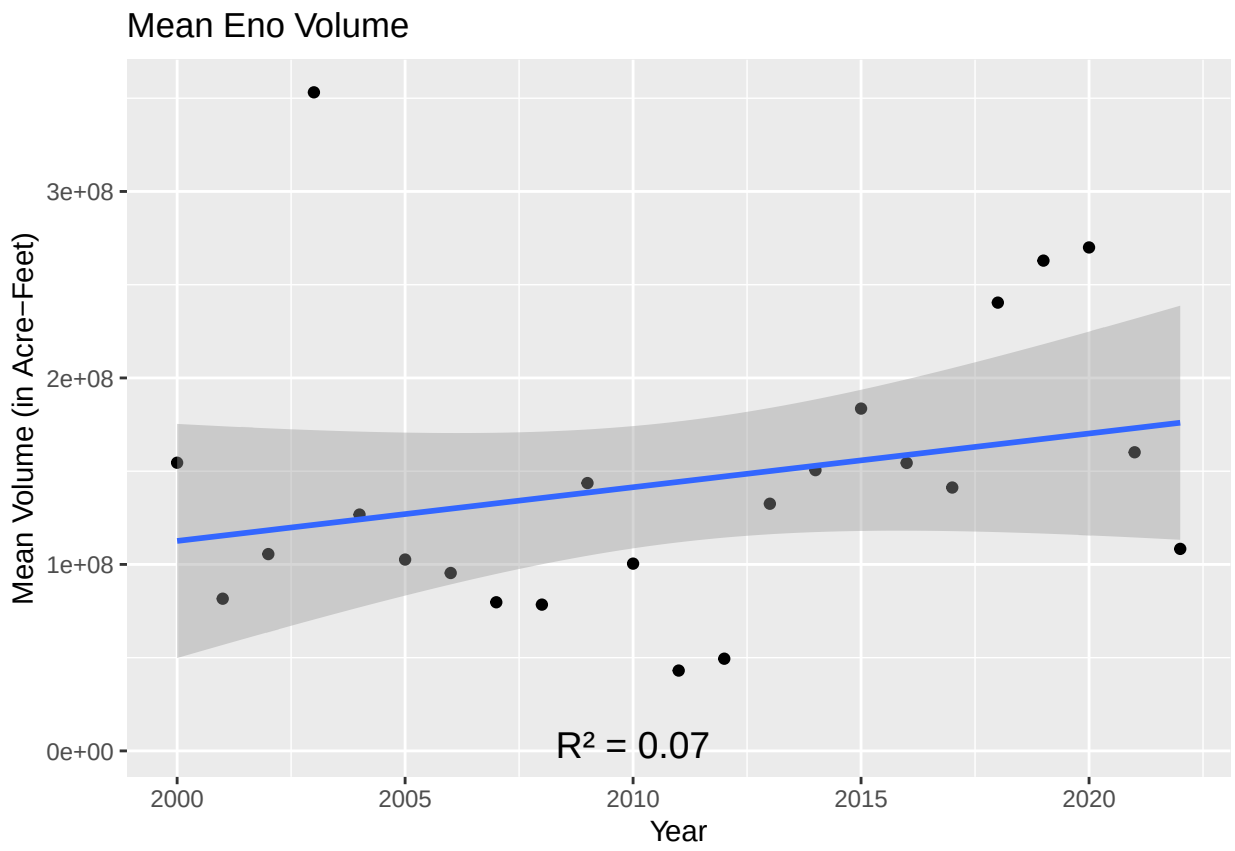



```
#Mean Eno volume
ggplot(data = eno_2000_volume) +
  geom_col(data = eno_2000_volume, aes(x = year, y = avg_vol)) +
  labs(title = "Mean Eno Volume", x = "Year", y = "Mean Volume (in Acre-Feet)")
```



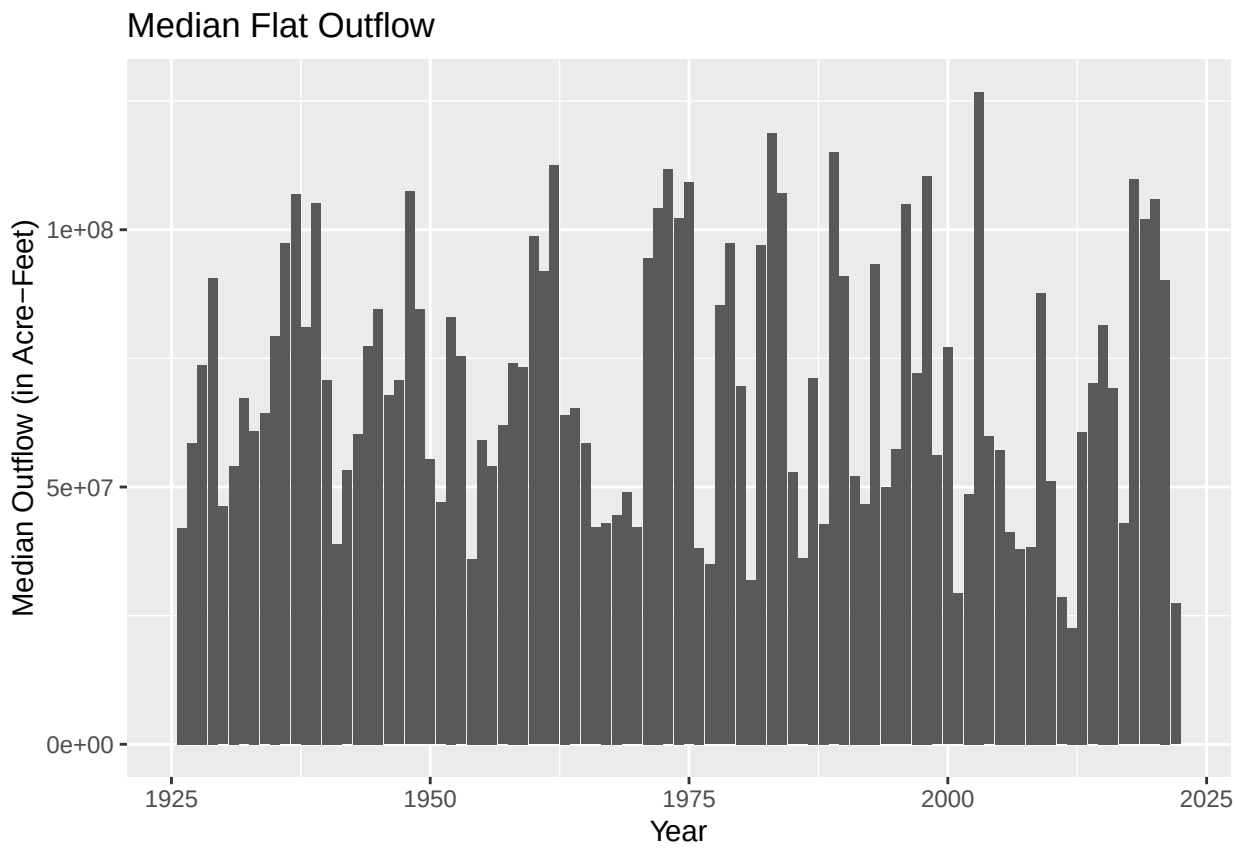

```
eno_vol_model_2000 <- lm(year ~ avg_vol, data = eno_2000_volume)
r_squared_9 <- summary(eno_vol_model_2000)$r.squared

ggplot(data = eno_2000_volume, aes(x = year, y = avg_vol)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Eno Volume", x = "Year", y = "Mean Volume (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(r_squared_9, 2)),
           size = 5)
```

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



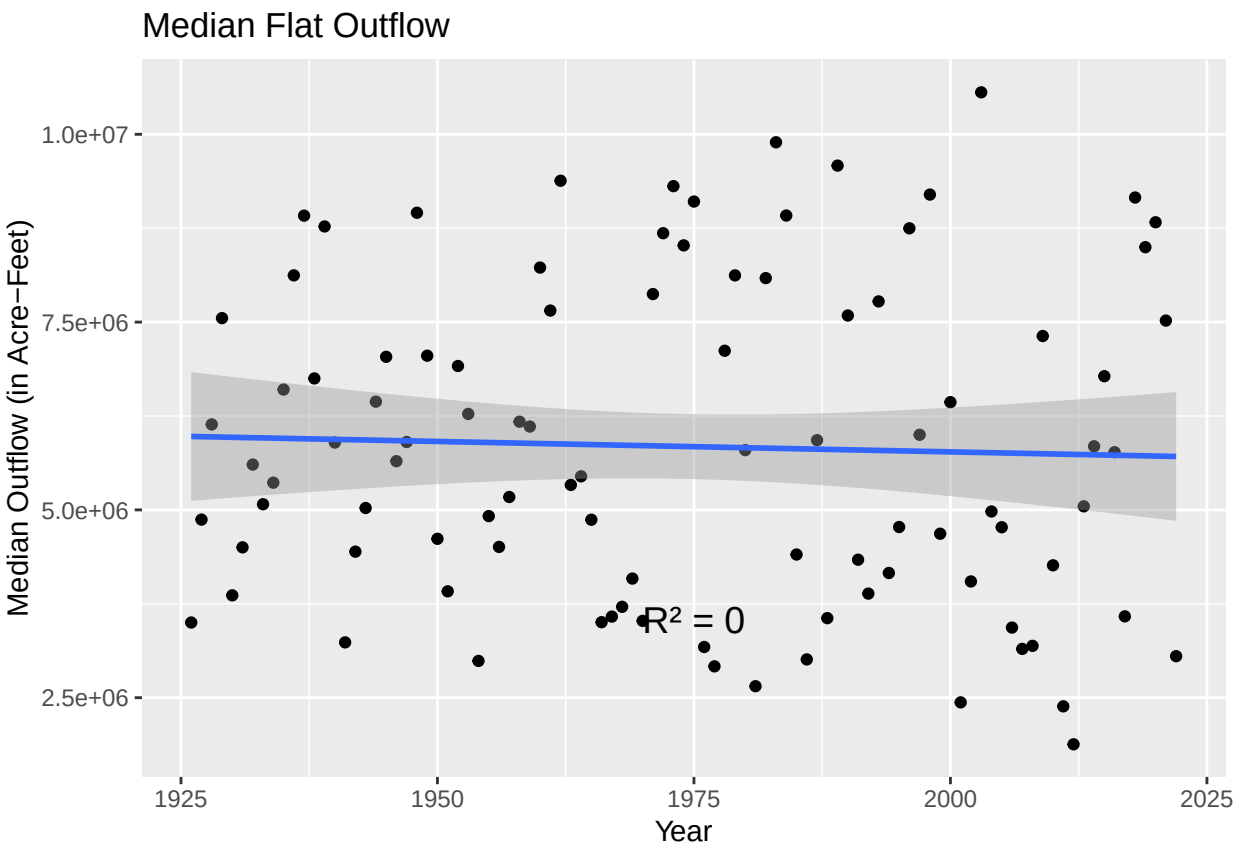

Now, we will look at Flat data.

```
#Median Flat outflow
ggplot(data = (flat_outflows)) +
  geom_col(data = flat_outflows, aes(x = year, y = median_flow)) +
  labs(title = "Median Flat Outflow", x = "Year", y = "Median Outflow (in Acre-Feet)")
```

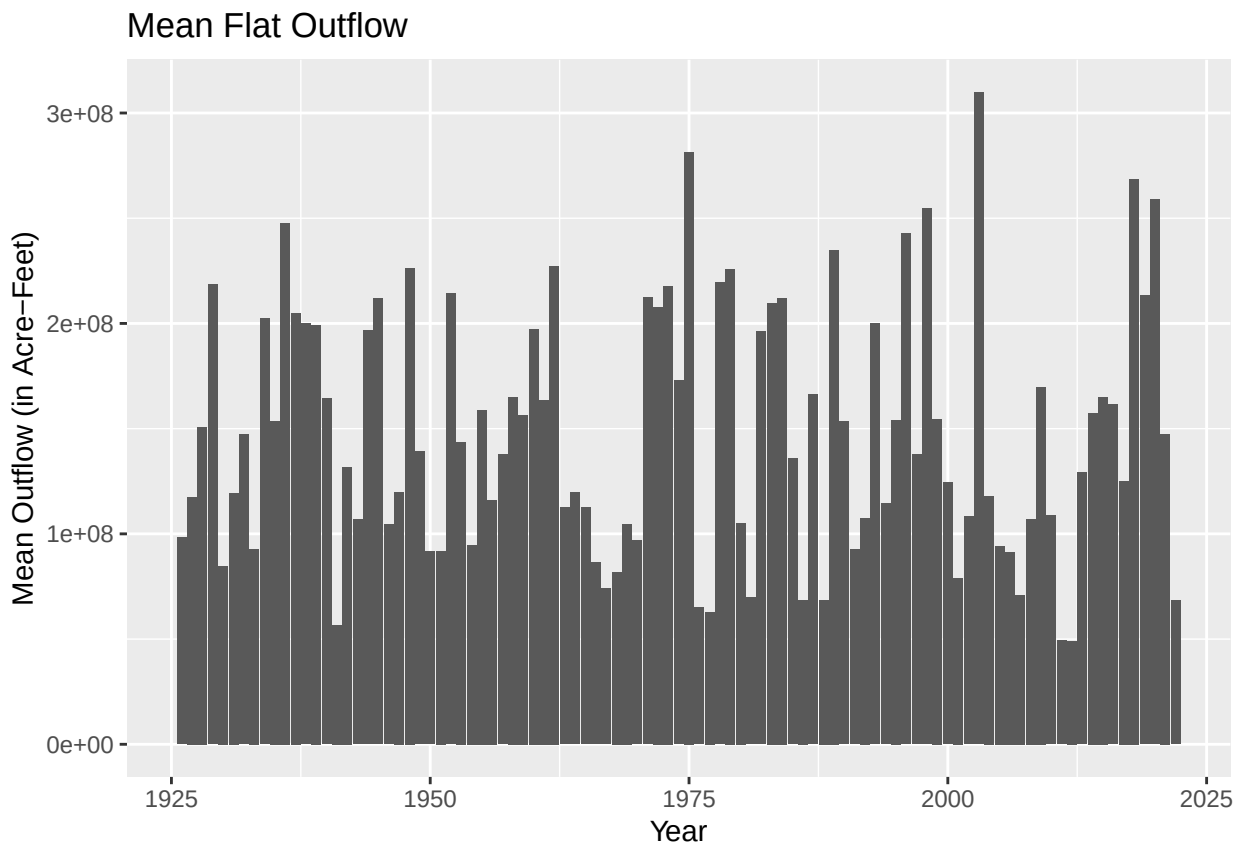



```
flat_med_model <- lm(year ~ avg_median_flow, data = flat_average_median)
flat_r <- summary(flat_med_model)$r.squared

ggplot(data = flat_average_median, aes(x = year, y = avg_median_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Median Flat Outflow", x = "Year", y = "Median Outflow (in Acre-Feet)") +
  annotate("text", x = 1975, y = 3542400,
           label = paste("R² =", round(flat_r, 2)),
           size = 5)
```

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

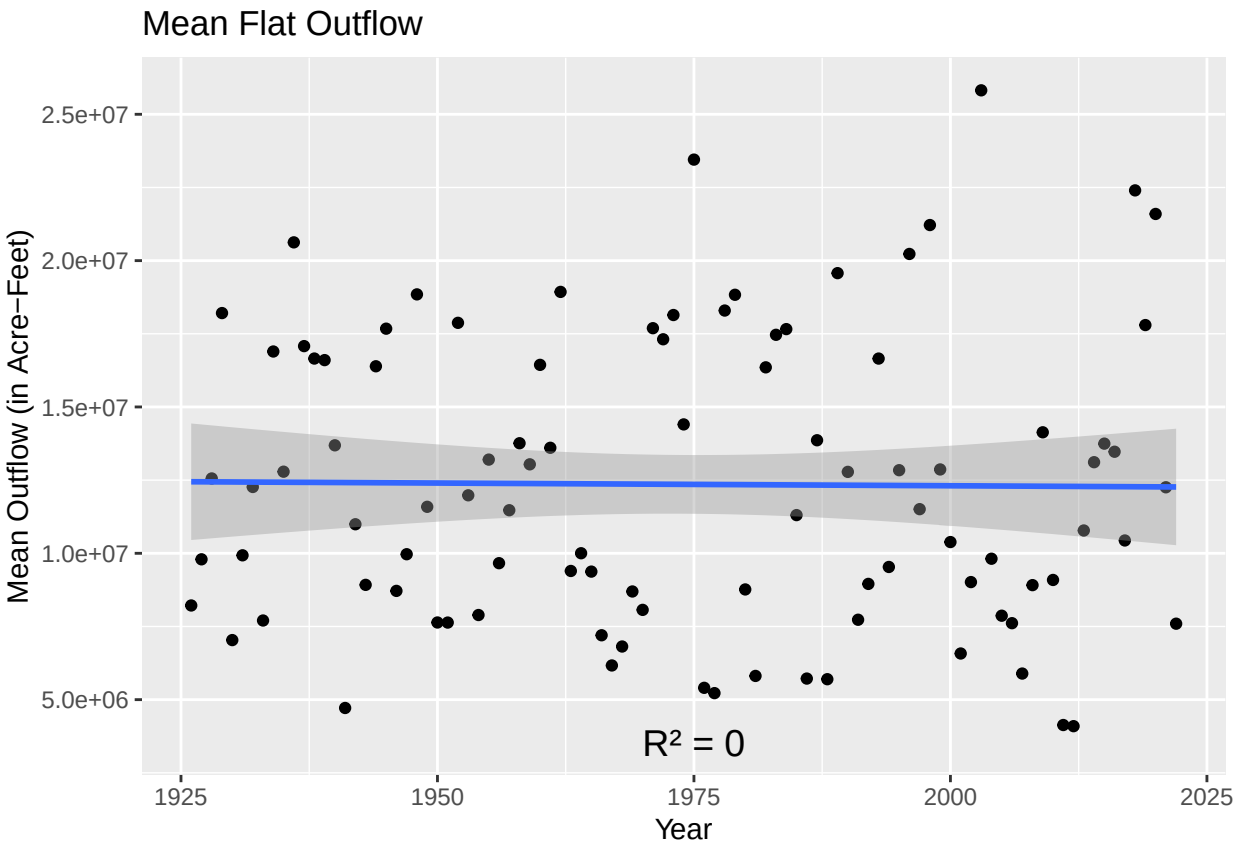



```
#Mean Flat outflow
ggplot(data = (flat_outflows)) +
  geom_col(data = flat_outflows, aes(x = year, y = mean_flow)) +
  labs(title = "Mean Flat Outflow", x = "Year", y = "Mean Outflow (in Acre-Feet)")
```

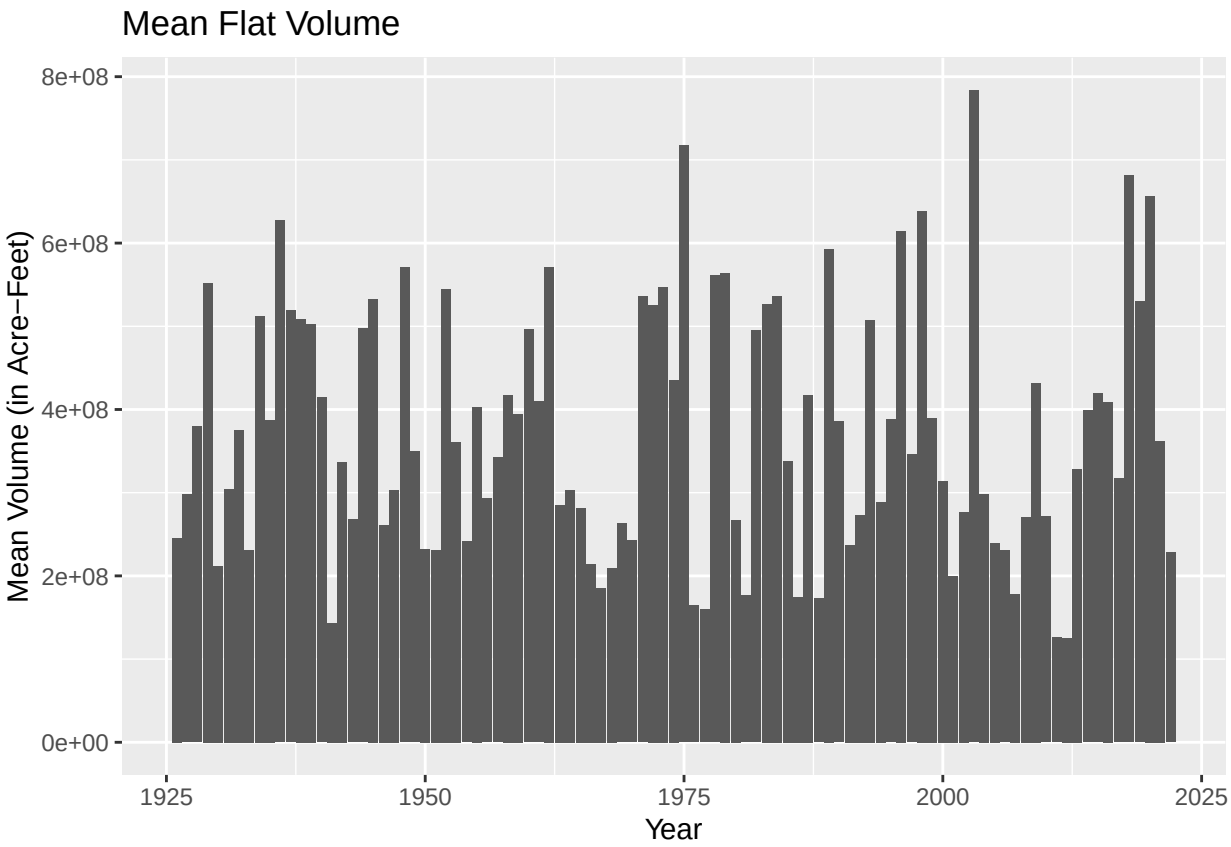



```
flat_mean_model <- lm(year ~ avg_mean_flow, data = flat_average_mean)
flat_r2 <- summary(flat_mean_model)$r.squared

ggplot(data = flat_average_mean, aes(x = year, y = avg_mean_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Flat Outflow", x = "Year", y = "Mean Outflow (in Acre-Feet)") +
    annotate("text", x = 1975, y = 3542400,
           label = paste("R² =", round(flat_r2, 2)),
           size = 5)
```

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

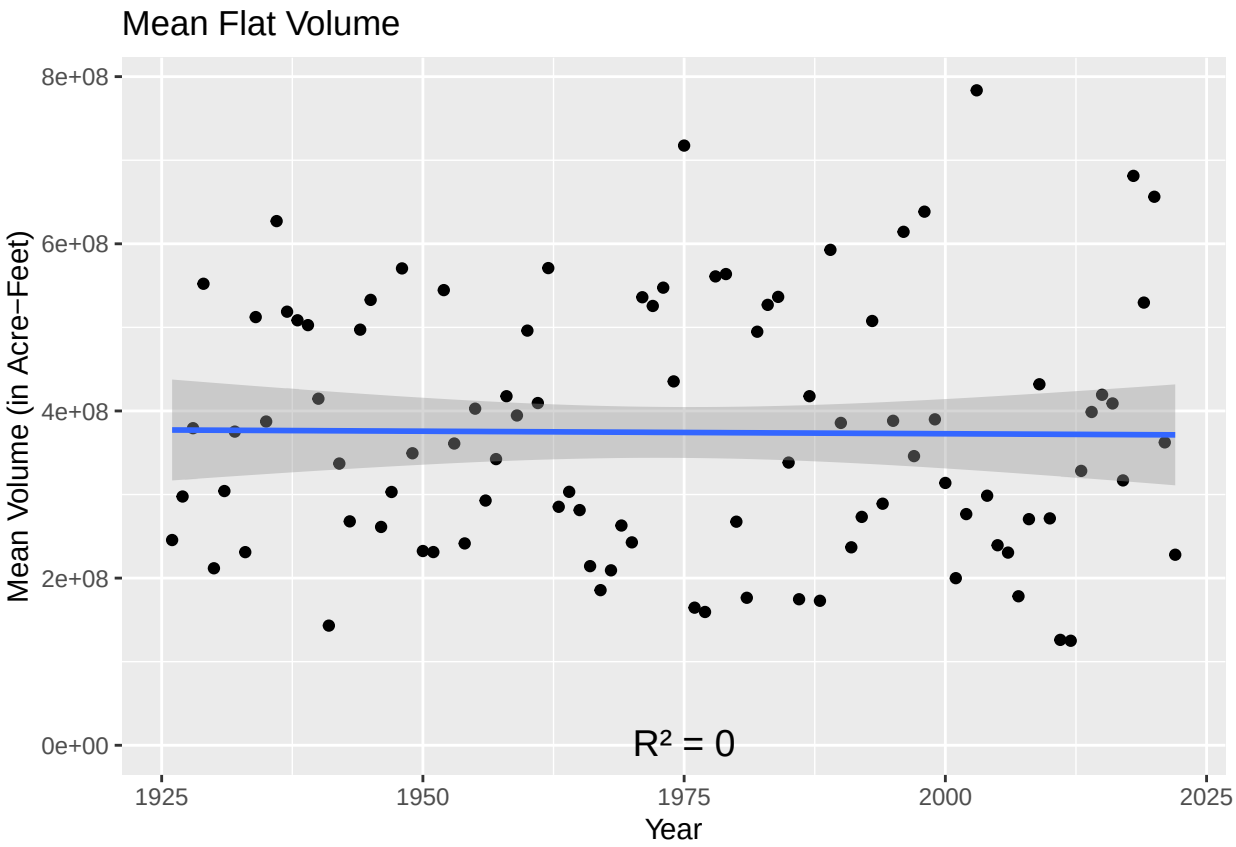



```
#Mean volume
ggplot(data = flat_volume_mean) +
  geom_col(data = flat_volume_mean, aes(x = year, y = avg_vol)) +
  labs(title = "Mean Flat Volume", x = "Year", y = "Mean Volume (in Acre-Feet)")
```



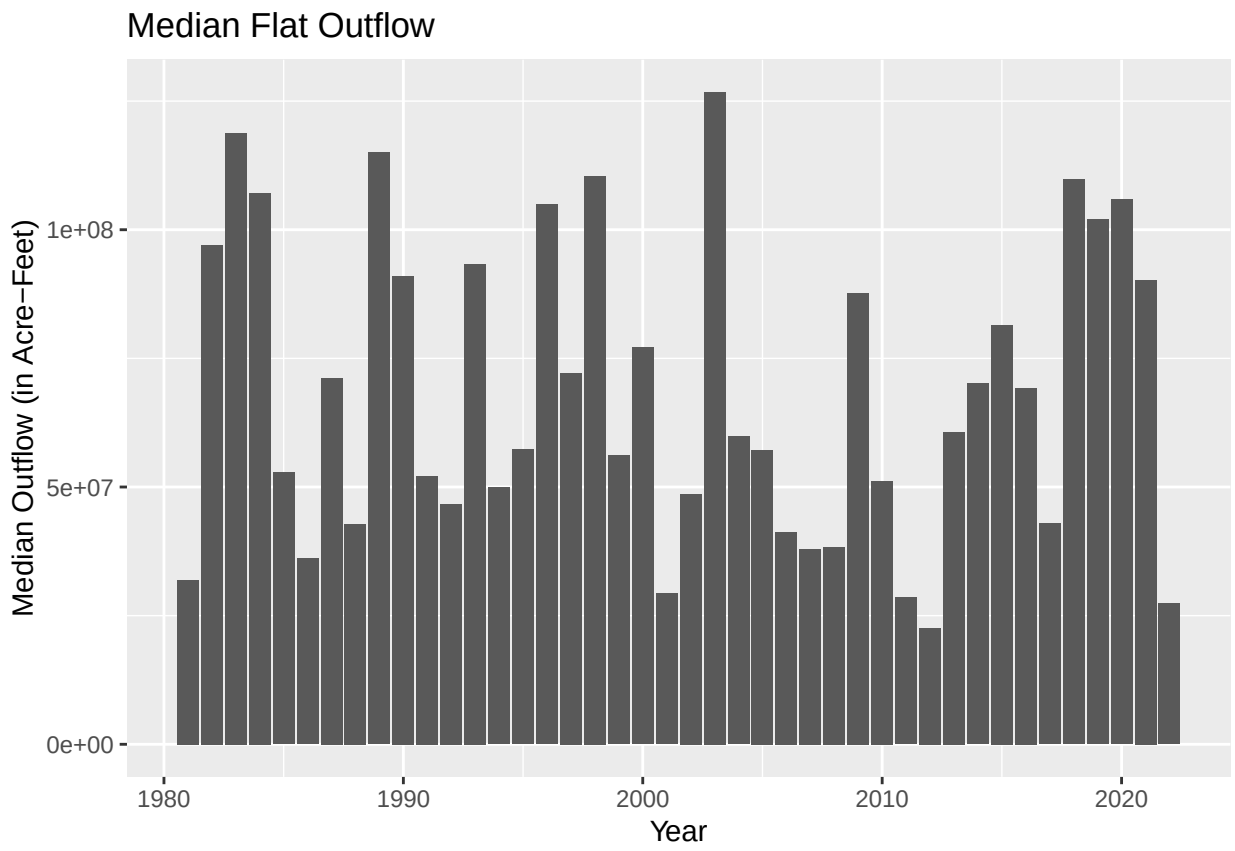

```
flat_vol_model <- lm(year ~ avg_vol, data = flat_volume_mean)
flat_r3 <- summary(flat_vol_model)$r.squared

ggplot(data = flat_volume_mean, aes(x = year, y = avg_vol)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Flat Volume", x = "Year", y = "Mean Volume (in Acre-Feet)") +
  annotate("text", x = 1975, y = 3542400,
           label = paste("R² =", round(flat_r3, 2)),
           size = 5)
```

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



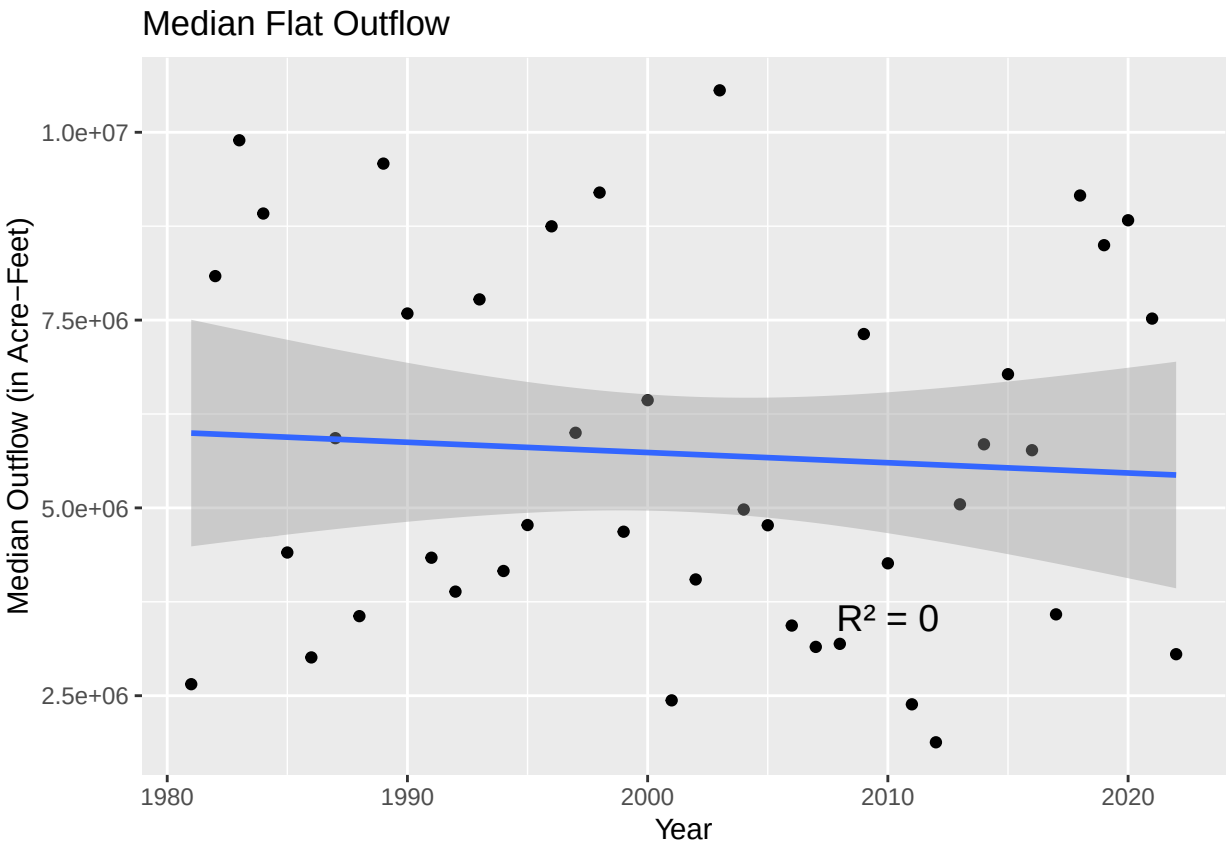

Now we will look at only years 1981 and beyond to capture recent trends.

```
#Filter out the data to only include 2000 and beyond.
flat_1981 <- flat_outflows %>%
  filter(year >= 1981)
#Filter out the average median outflow data to only include 2000 and beyond.
flat_1981_median <- flat_average_median %>%
  filter(year >= 1981)
#Filter out the average mean outflow data to only include 2000 and beyond.
flat_1981_mean <- flat_average_mean %>%
  filter(year >= 1981)
#Filter out the average volume data to only include 2000 and beyond.
flat_1981_volume <- flat_volume_mean %>%
  filter(year >= 1981)

#Median Flat outflow
ggplot(data = flat_1981) +
  geom_col(data = flat_1981, aes(x = year, y = median_flow)) +
  labs(title = "Median Flat Outflow", x = "Year", y = "Median Outflow (in Acre-Feet)")
```

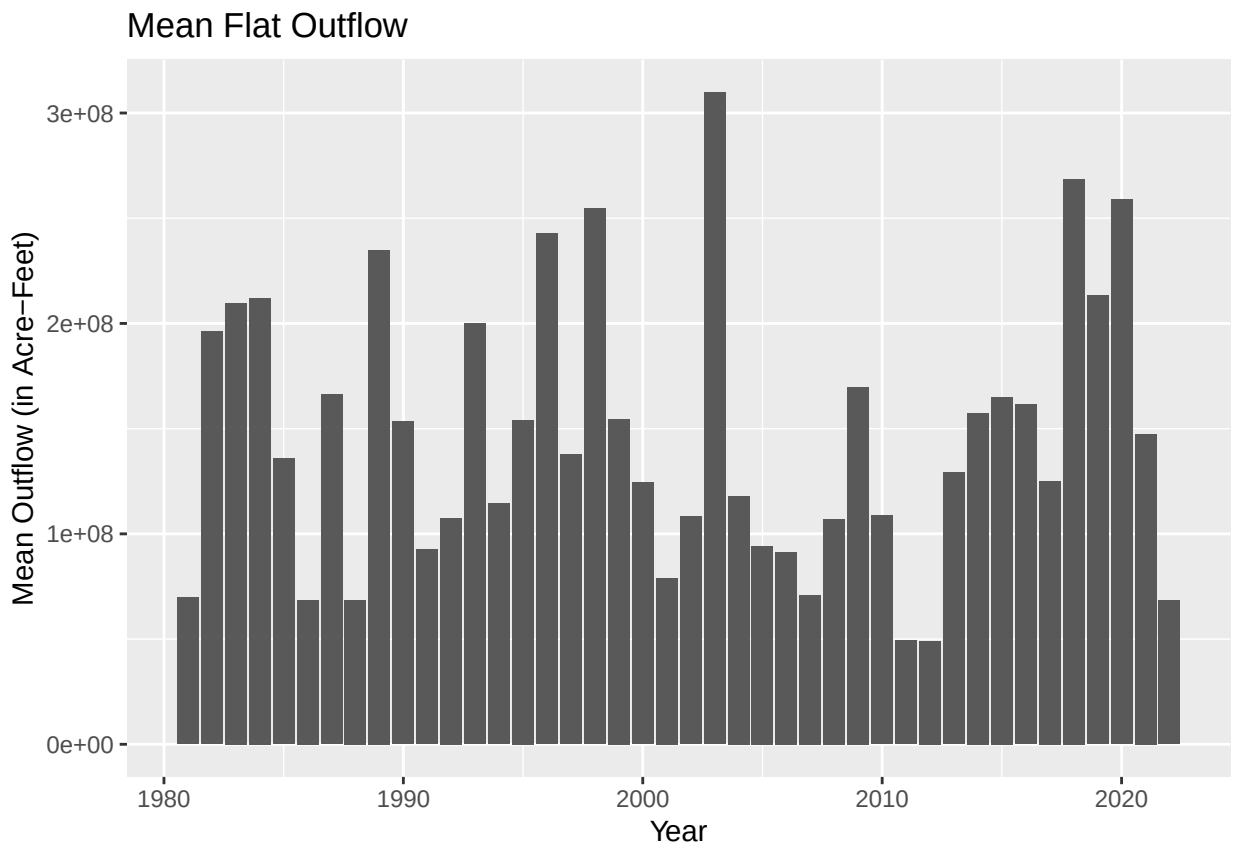



```
flat_med_model_1981 <- lm(year ~ avg_median_flow, data = flat_1981_median)
flat_r4 <- summary(flat_med_model_1981)$r.squared

ggplot(data = flat_1981_median, aes(x = year, y = avg_median_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Median Flat Outflow", x = "Year", y = "Median Outflow (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(flat_r4, 2)),
           size = 5)
```

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

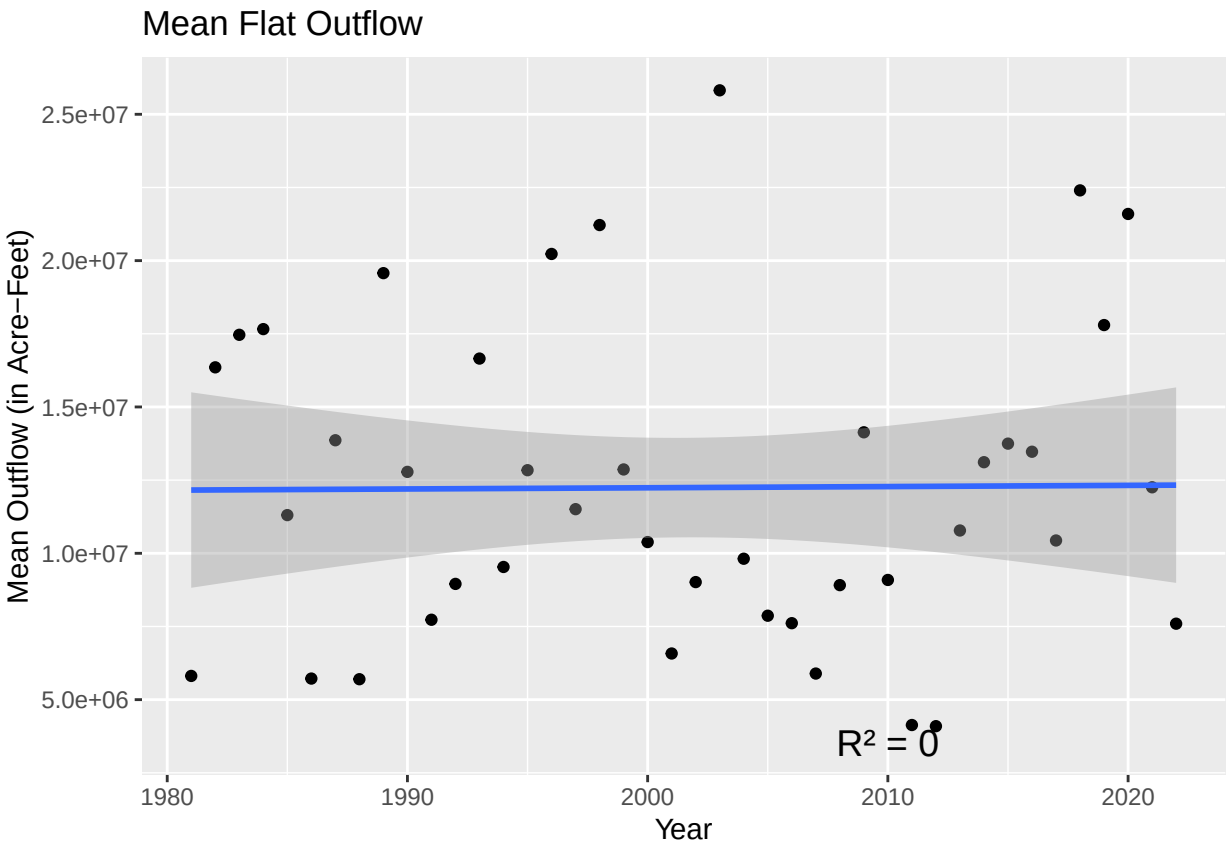



```
#Mean Flat outflow
ggplot(data = flat_1981) +
  geom_col(data = flat_1981, aes(x = year, y = mean_flow)) +
  labs(title = "Mean Flat Outflow", x = "Year", y = "Mean Outflow (in Acre-Feet)")
```

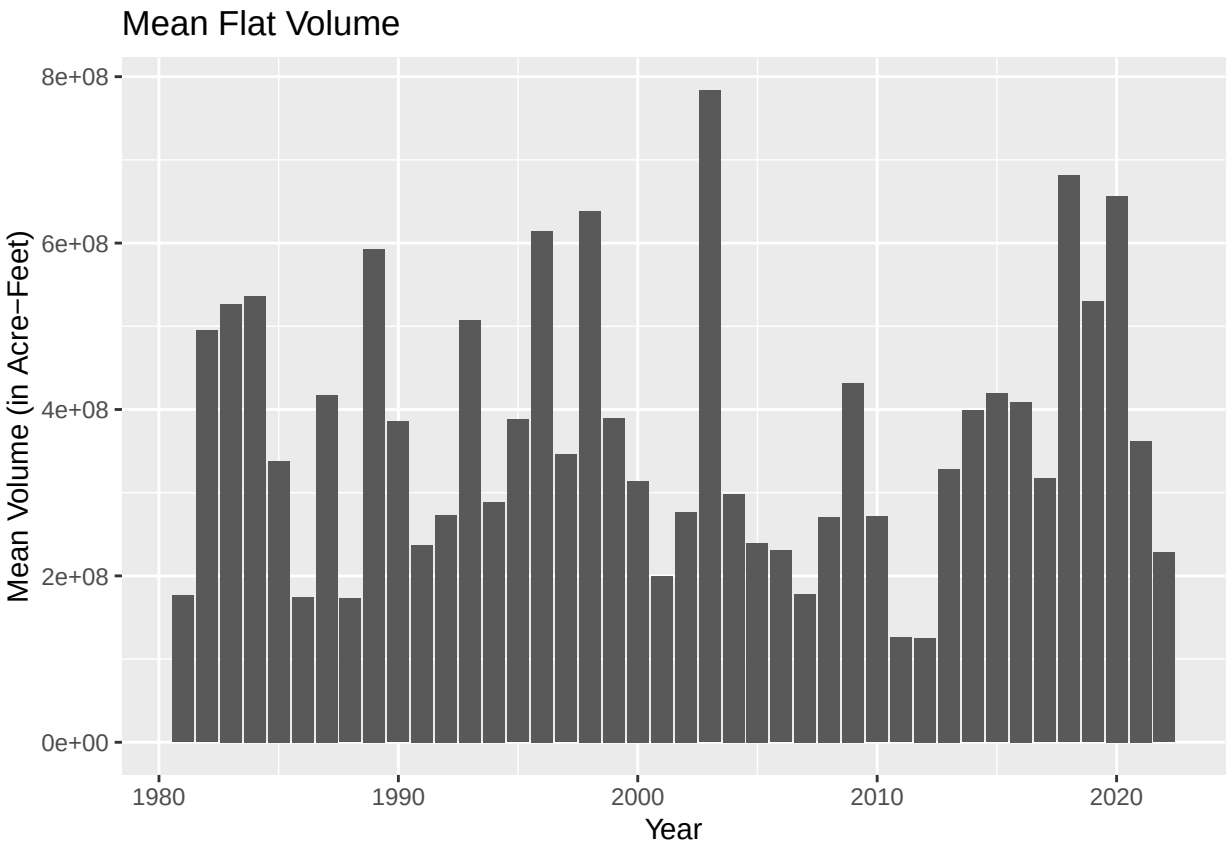



```
flat_mean_model_1981 <- lm(year ~ avg_mean_flow, data = flat_1981_mean)
flat_r5 <- summary(flat_mean_model_1981)$r.squared

ggplot(data = flat_1981_mean, aes(x = year, y = avg_mean_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Flat Outflow", x = "Year", y = "Mean Outflow (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(flat_r5, 2)),
           size = 5)
```

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

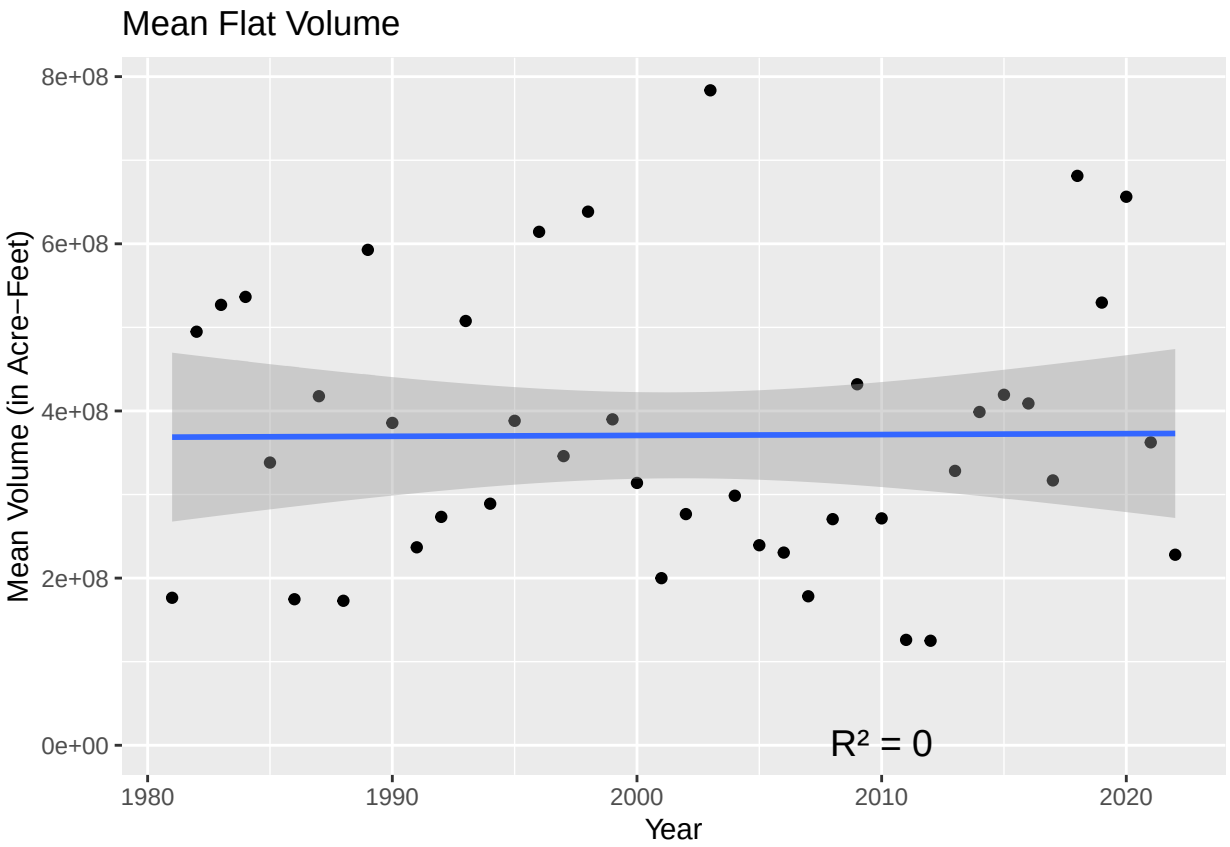



```
#Mean Flat volume
ggplot(data = flat_1981_volume) +
  geom_col(data = flat_1981_volume, aes(x = year, y = avg_vol)) +
  labs(title = "Mean Flat Volume", x = "Year", y = "Mean Volume (in Acre-Feet)")
```



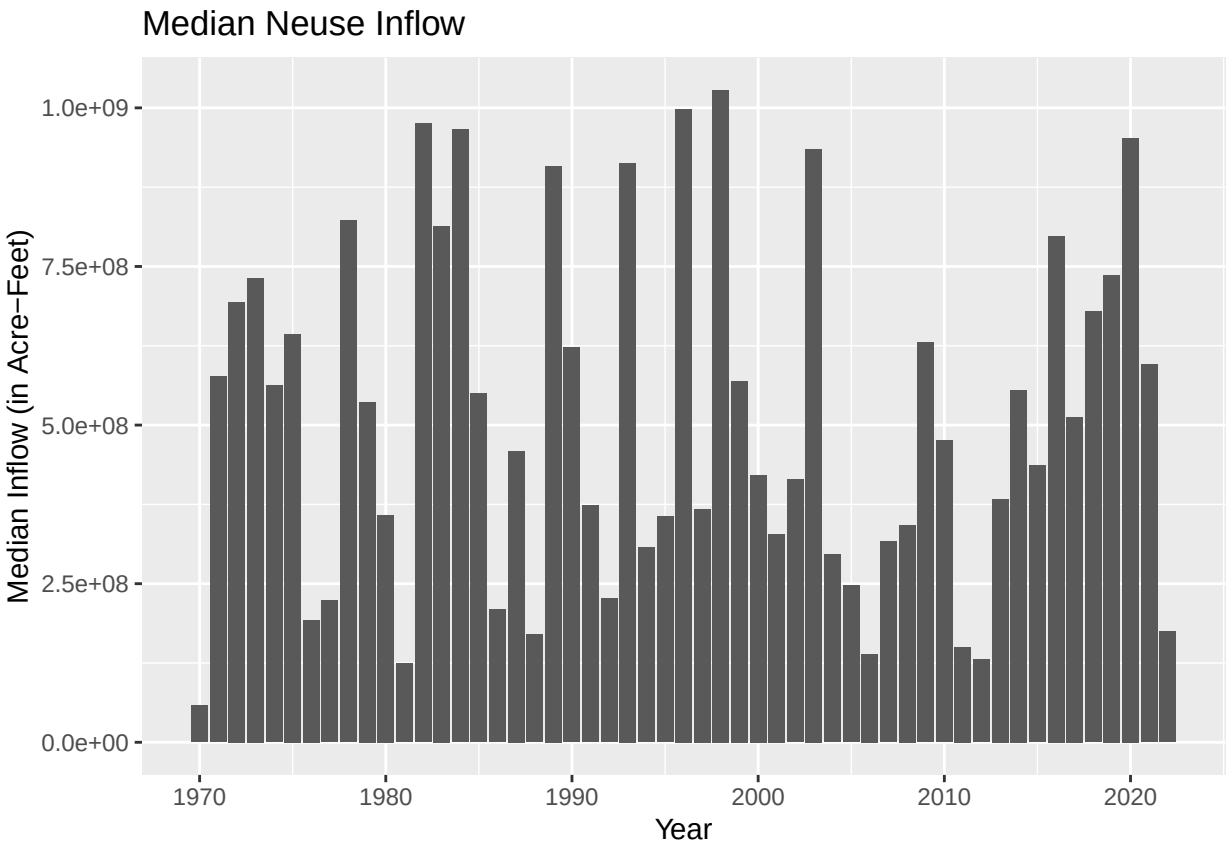

```
flat_vol_model_1981 <- lm(year ~ avg_vol, data = flat_1981_volume)
flat_r6 <- summary(flat_vol_model_1981)$r.squared

ggplot(data = flat_1981_volume, aes(x = year, y = avg_vol)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Flat Volume", x = "Year", y = "Mean Volume (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(flat_r6, 2)),
           size = 5)
```

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



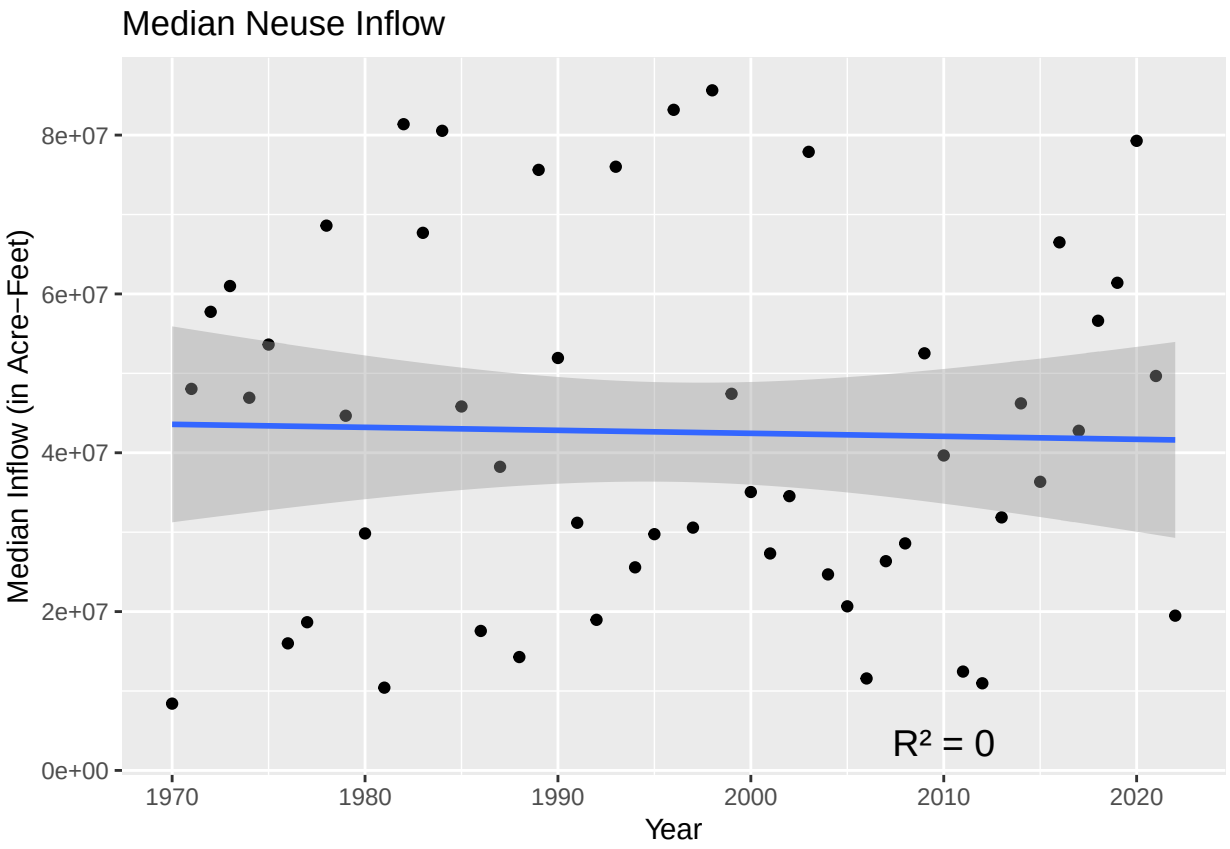

Finally, we will look at Neuse inflows.

```
#Median Neuse inflow
ggplot(data = (neuse_inflows)) +
  geom_col(data = neuse_inflows, aes(x = year, y = median_flow)) +
  labs(title = "Median Neuse Inflow", x = "Year", y = "Median Inflow (in Acre-Feet)")
```

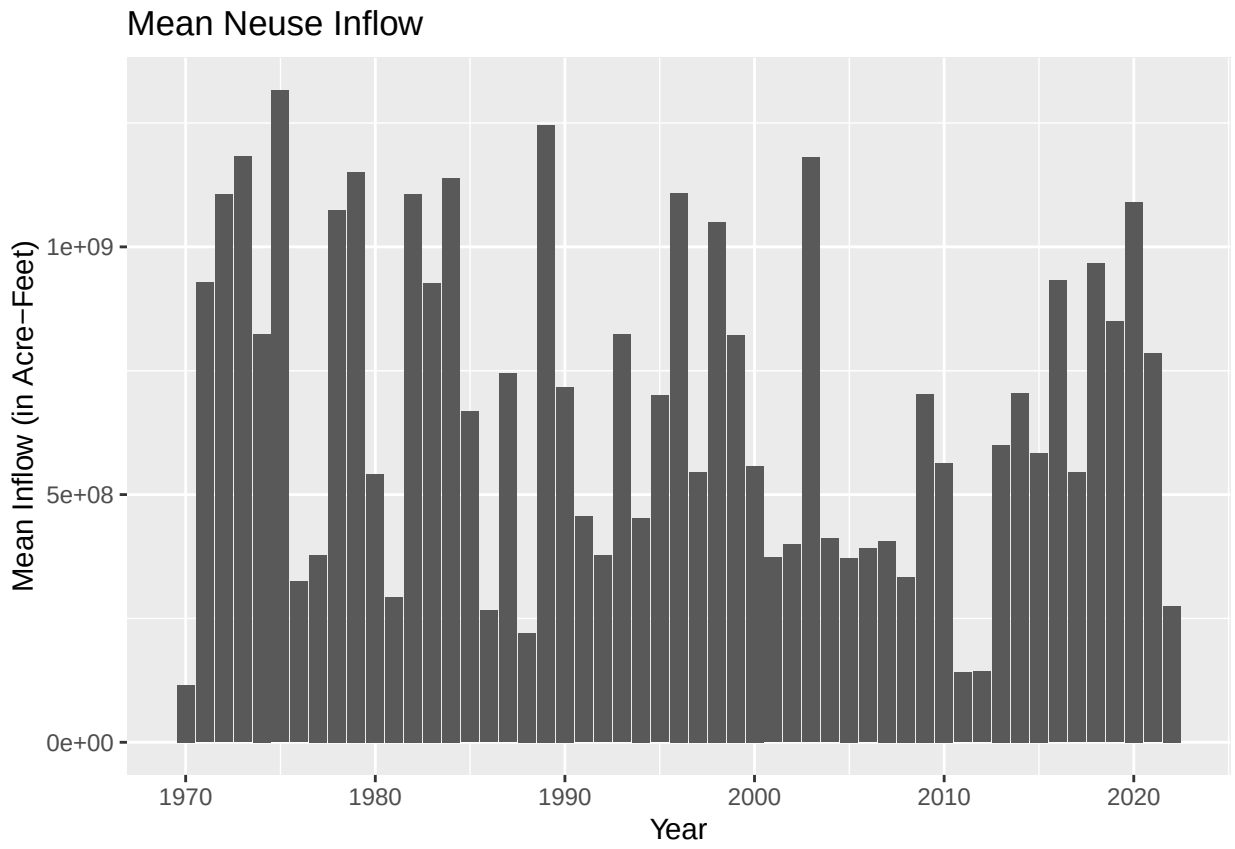



```
neuse_med_model <- lm(year ~ avg_median_flow, data = neuse_average_median)
neuse_r <- summary(neuse_med_model)$r.squared

ggplot(data = neuse_average_median, aes(x = year, y = avg_median_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Median Neuse Inflow", x = "Year", y = "Median Inflow (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(neuse_r, 2)),
           size = 5)
```

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

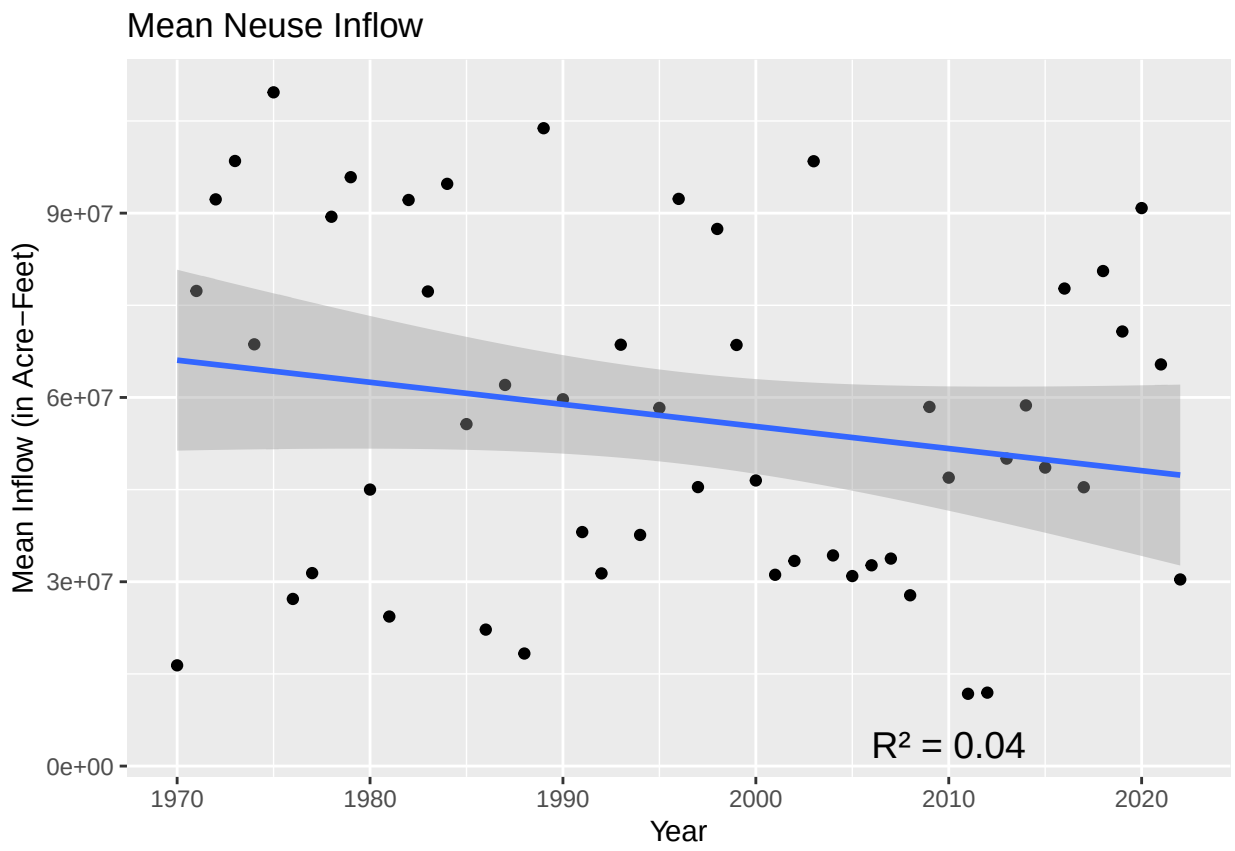



```
#Mean Neuse inflow
ggplot(data = neuse_inflows) +
  geom_col(data = neuse_inflows, aes(x = year, y = mean_flow)) +
  labs(title = "Mean Neuse Inflow", x = "Year", y = "Mean Inflow (in Acre-Feet)")
```

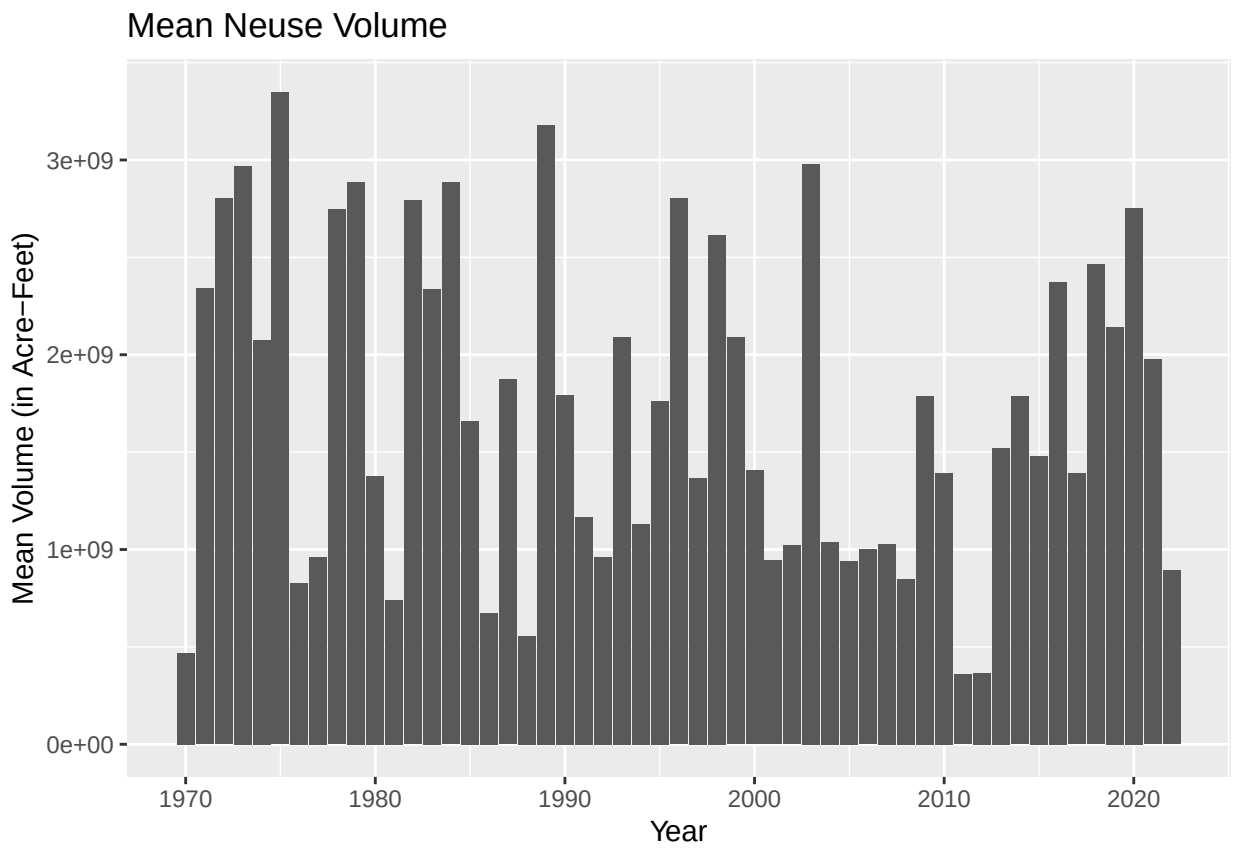



```
neuse_mean_model <- lm(year ~ avg_mean_flow, data = neuse_average_mean)
neuse_r2 <- summary(neuse_mean_model)$r.squared

ggplot(data = neuse_average_mean, aes(x = year, y = avg_mean_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Neuse Inflow", x = "Year", y = "Mean Inflow (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(neuse_r2, 2)),
           size = 5)
```

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

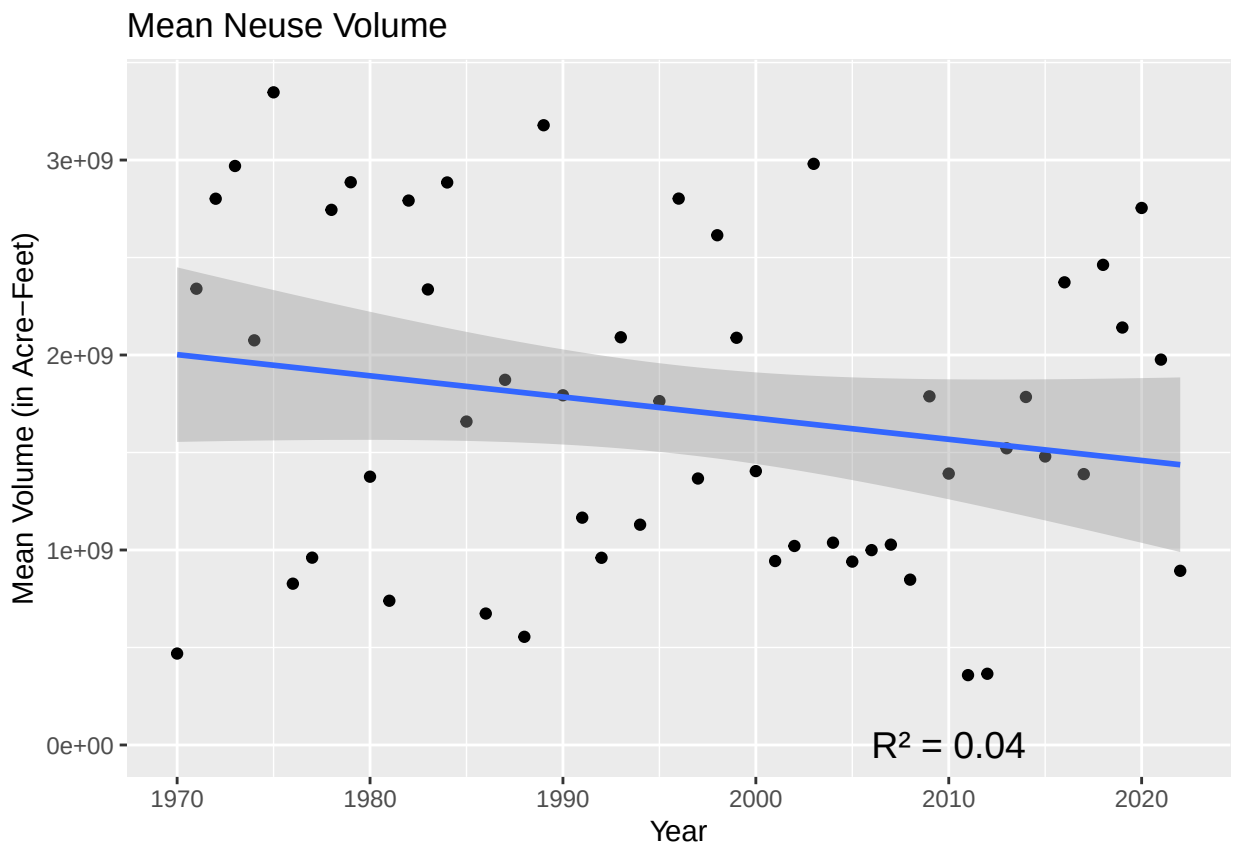



```
#Mean volume
ggplot(data = neuse_volume_mean) +
  geom_col(data = neuse_volume_mean, aes(x = year, y = avg_vol)) +
  labs(title = "Mean Neuse Volume", x = "Year", y = "Mean Volume (in Acre-Feet)")
```



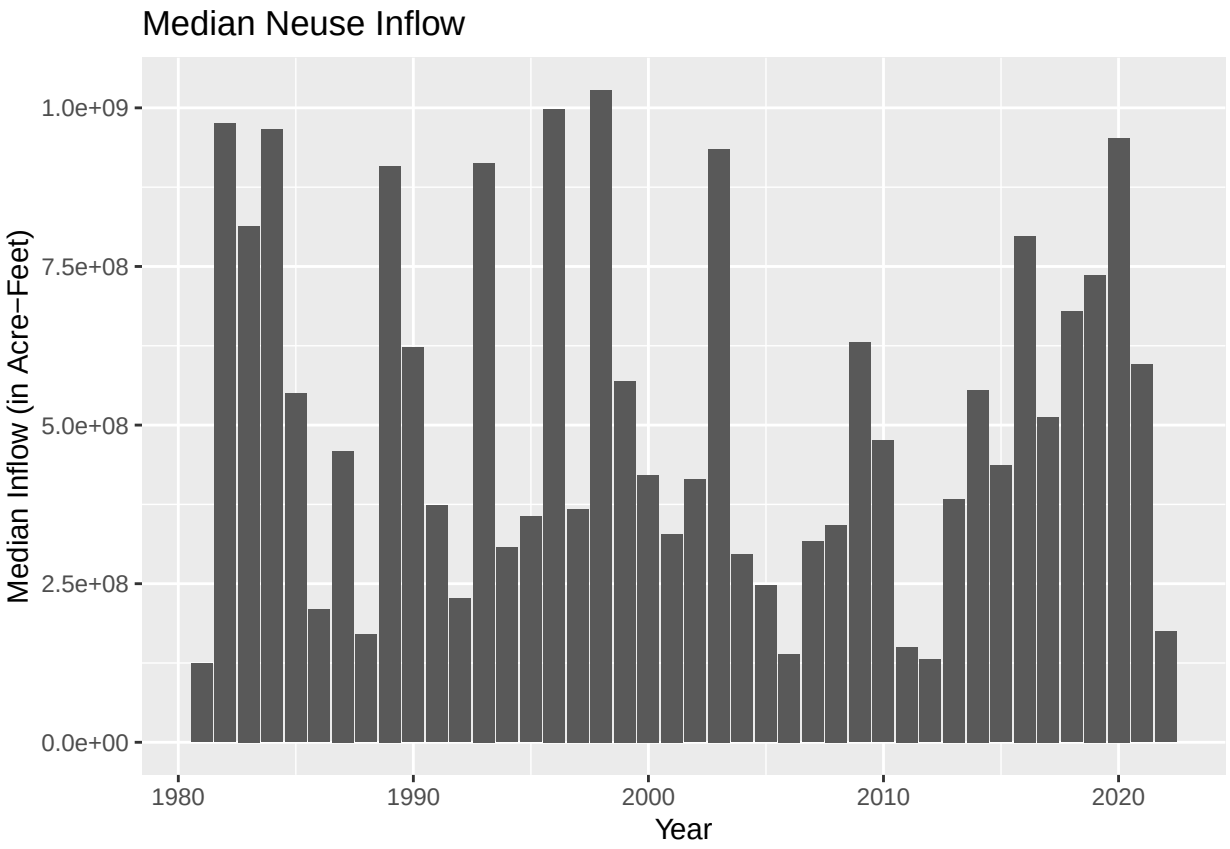

```
neuse_vol_model <- lm(year ~ avg_vol, data = neuse_volume_mean)
neuse_r3 <- summary(neuse_vol_model)$r.squared

ggplot(data = neuse_volume_mean, aes(x = year, y = avg_vol)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Neuse Volume", x = "Year", y = "Mean Volume (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(neuse_r3, 2)),
           size = 5)
```

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



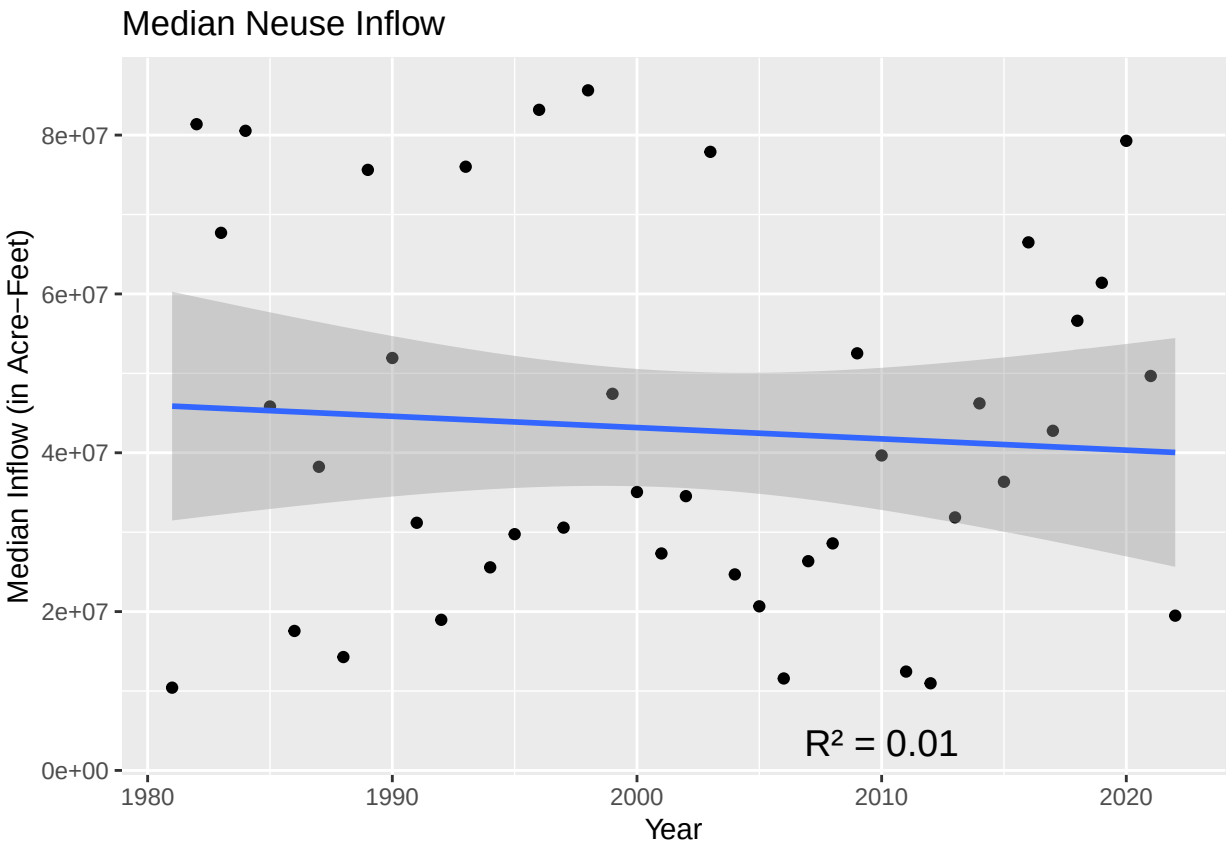

And now with only 1981 and beyond:

```
#Filter out the data to only include 2000 and beyond.
neuse_1981 <- neuse_inflows %>%
  filter(year >= 1981)
#Filter out the average median outflow data to only include 2000 and beyond.
neuse_1981_median <- neuse_average_median %>%
  filter(year >= 1981)
#Filter out the average mean outflow data to only include 2000 and beyond.
neuse_1981_mean <- neuse_average_mean %>%
  filter(year >= 1981)
#Filter out the average volume data to only include 2000 and beyond.
neuse_1981_volume <- neuse_volume_mean %>%
  filter(year >= 1981)

#Median Neuse inflow
ggplot(data = (neuse_1981)) +
  geom_col(data = neuse_1981, aes(x = year, y = median_flow)) +
  labs(title = "Median Neuse Inflow", x = "Year", y = "Median Inflow (in Acre-Feet)")
```

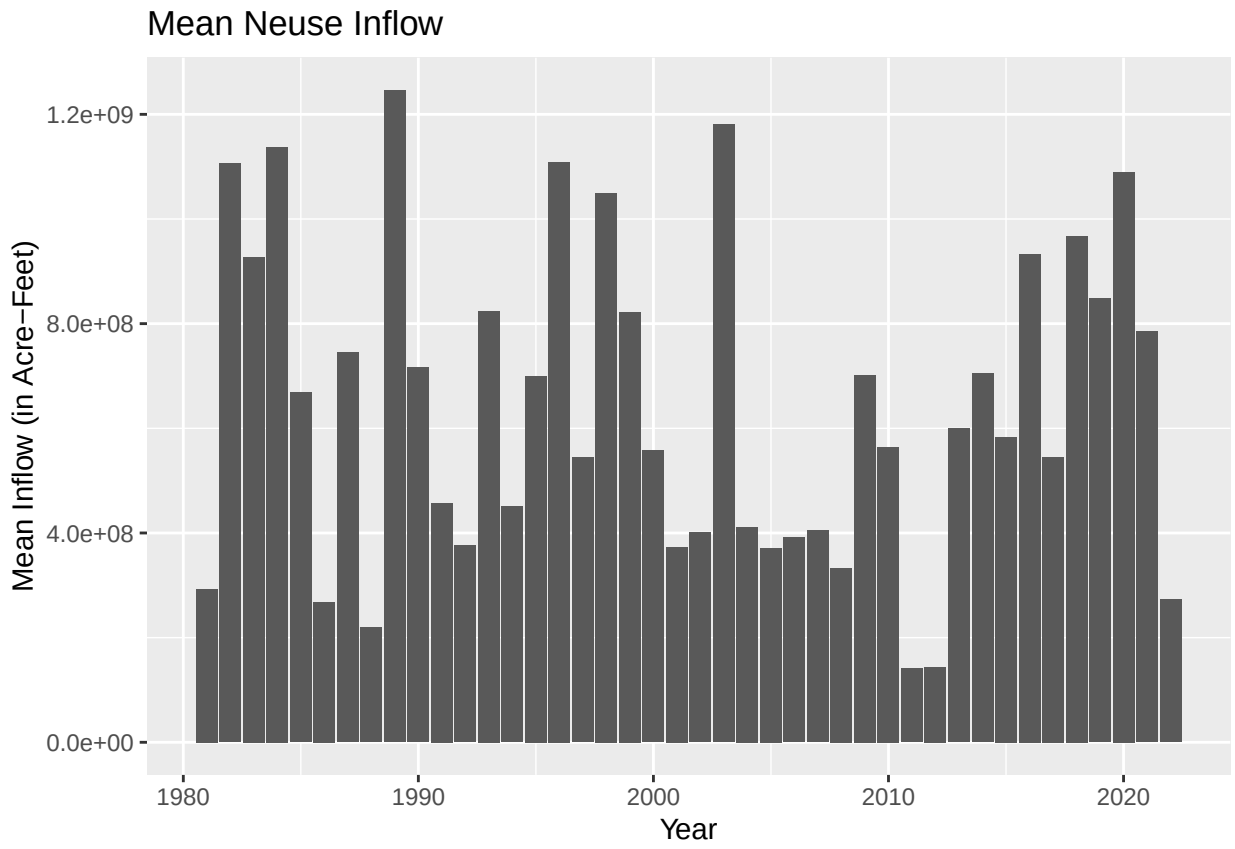



```
neuse_med_model_1981 <- lm(year ~ avg_median_flow, data = neuse_1981_median)
neuse_r4 <- summary(neuse_med_model_1981)$r.squared

ggplot(data = neuse_1981_median, aes(x = year, y = avg_median_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Median Neuse Inflow", x = "Year", y = "Median Inflow (in Acre-Feet)") +
  annotate("text", x = 2010, y = 3542400,
           label = paste("R² =", round(neuse_r4, 2)),
           size = 5)
```

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

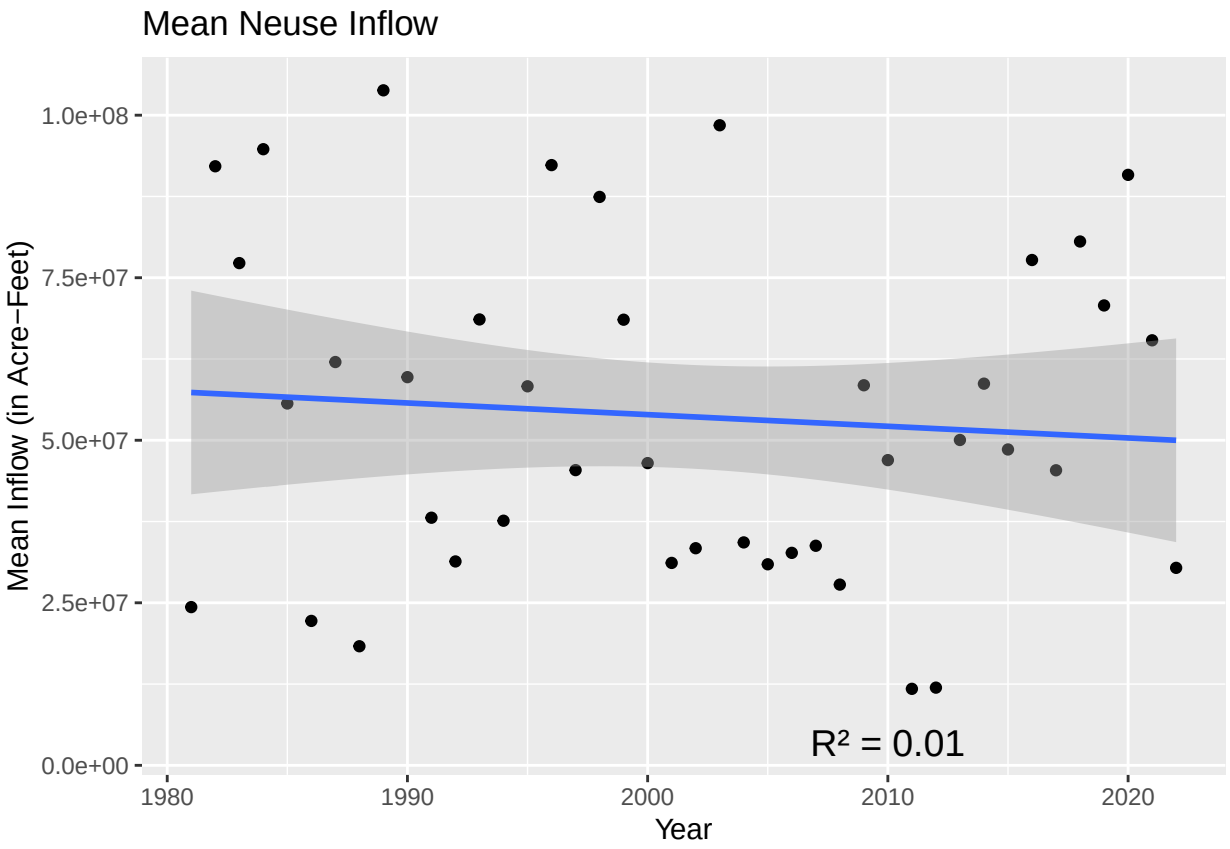



```
#Mean Neuse inflow
ggplot(data = neuse_1981) +
  geom_col(data = neuse_1981, aes(x = year, y = mean_flow)) +
  labs(title = "Mean Neuse Inflow", x = "Year", y = "Mean Inflow (in Acre-Feet)")
```

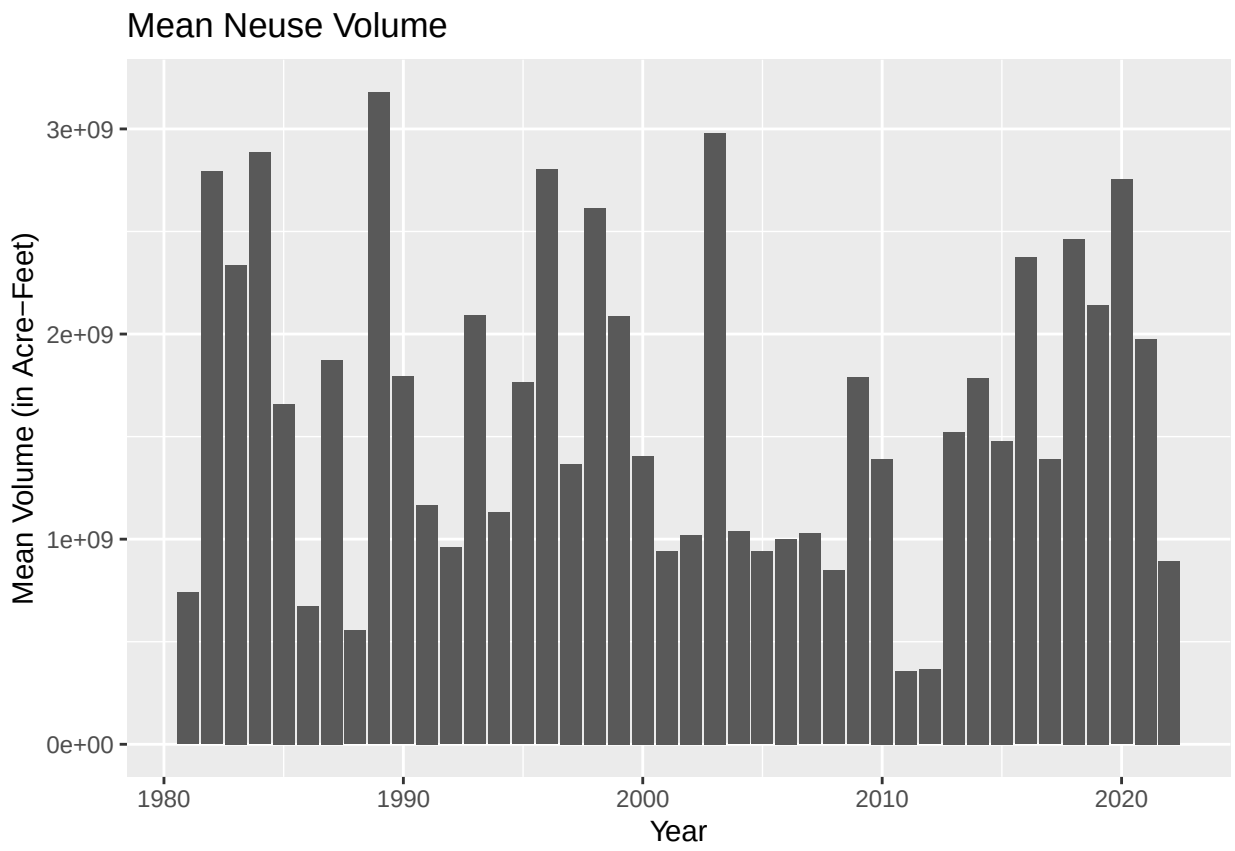



```
neuse_mean_model_1981 <- lm(year ~ avg_mean_flow, data = neuse_1981_mean)
neuse_r5 <- summary(neuse_mean_model_1981)$r.squared

ggplot(data = neuse_1981_mean, aes(x = year, y = avg_mean_flow)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Neuse Inflow", x = "Year", y = "Mean Inflow (in Acre-Feet)") +
   annotate("text", x = 2010, y = 3542400,
            label = paste("R² =", round(neuse_r5, 2)),
            size = 5)
```

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

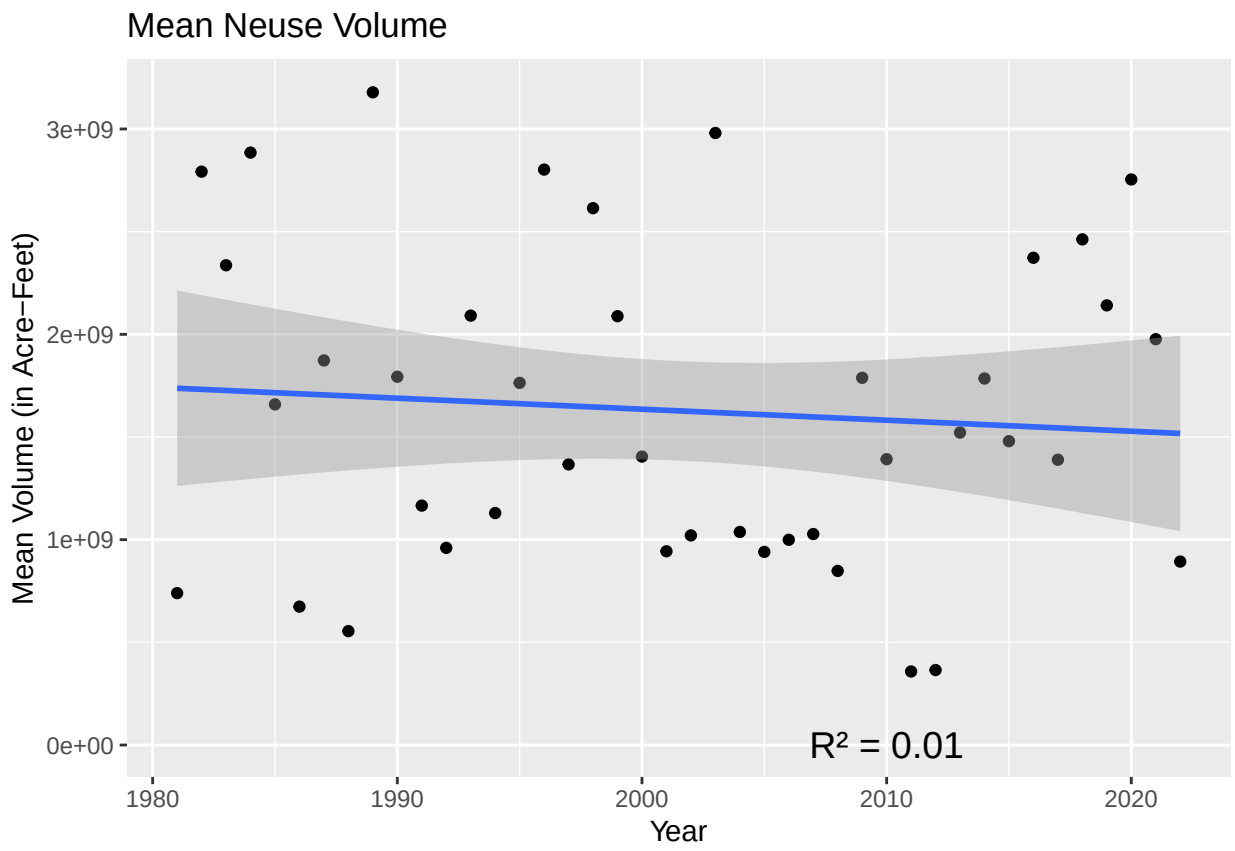



```
#Mean Neuse volume
ggplot(data = neuse_1981_volume) +
  geom_col(data = neuse_1981_volume, aes(x = year, y = avg_vol)) +
  labs(title = "Mean Neuse Volume", x = "Year", y = "Mean Volume (in Acre-Feet)")
```



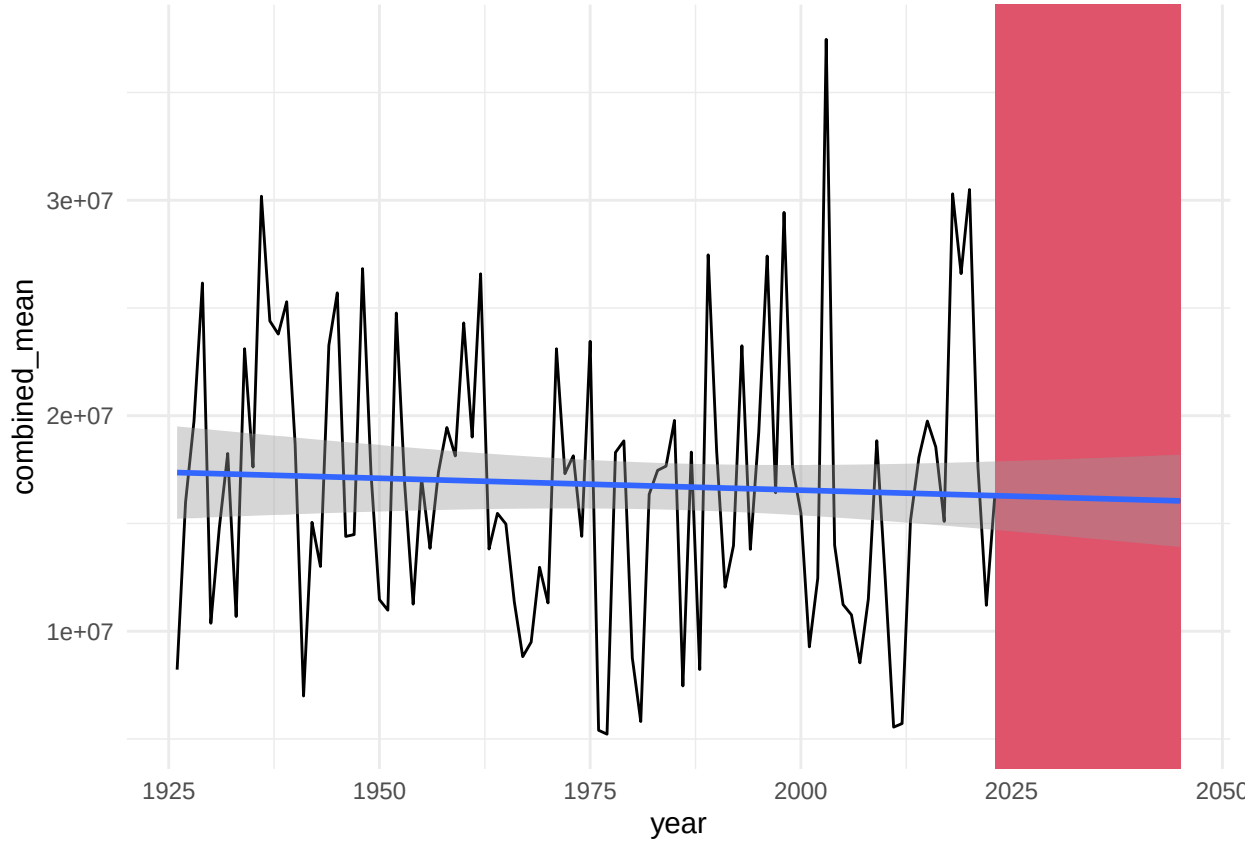

```
neuse_vol_model_1981 <- lm(year ~ avg_vol, data = neuse_1981_volume)
neuse_r6 <- summary(neuse_vol_model_1981)$r.squared

ggplot(data = neuse_1981_volume, aes(x = year, y = avg_vol)) +
  geom_point() +
  geom_smooth(method = "lm") +
  labs(title = "Mean Neuse Volume", x = "Year", y = "Mean Volume (in Acre-Feet)") +
   annotate("text", x = 2010, y = 3542400,
            label = paste("R² =", round(neuse_r6, 2)),
            size = 5)
```

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



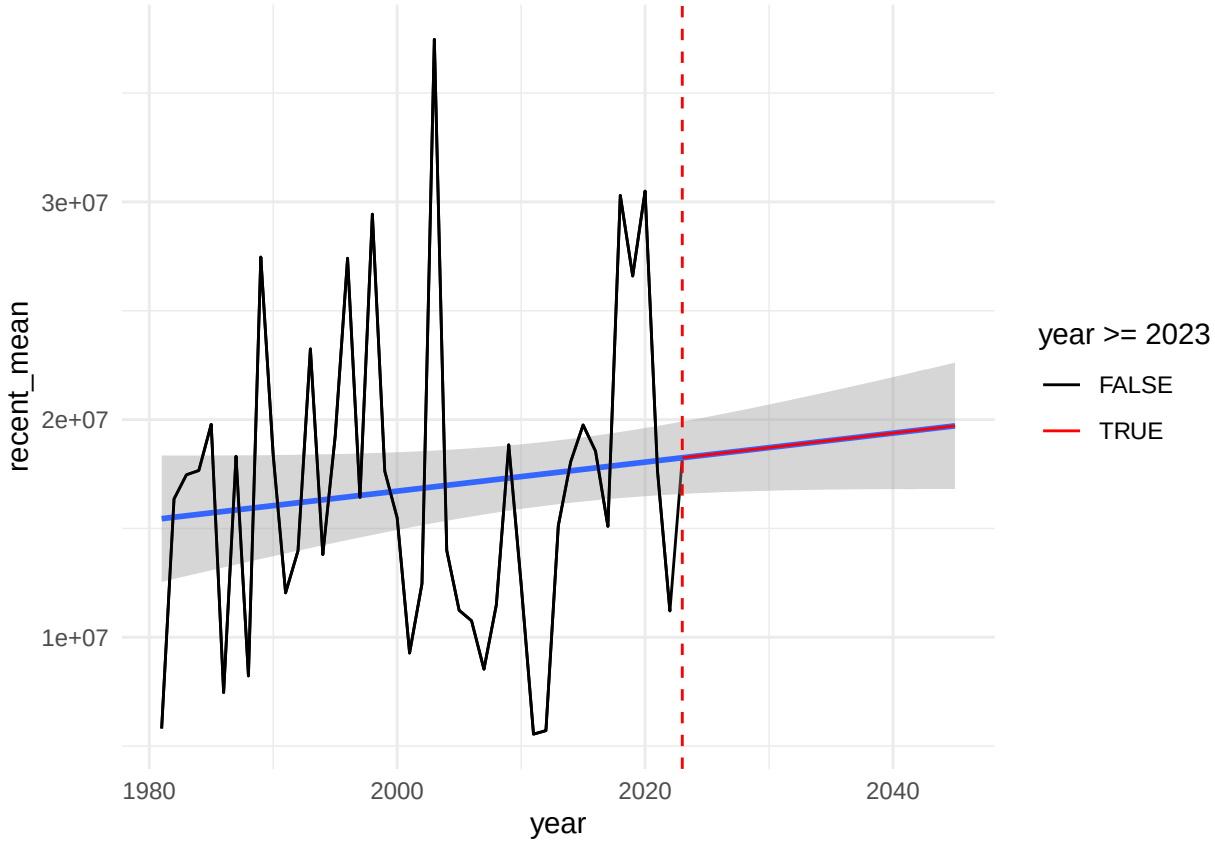

```
library(readxl)
combined <- read_xlsx("./Data Raw/combined_mean.xlsx")

library(ggpattern)
ggplot(data = combined, aes(x = year, y = combined_mean)) +
  geom_rect(aes(xmin = 2023, xmax = 2045, ymin = -Inf, ymax = Inf),
            fill = "50f8cd", alpha = 0.5) +
  theme_minimal() +
  geom_line() +
  geom_smooth(method = "lm")
```

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



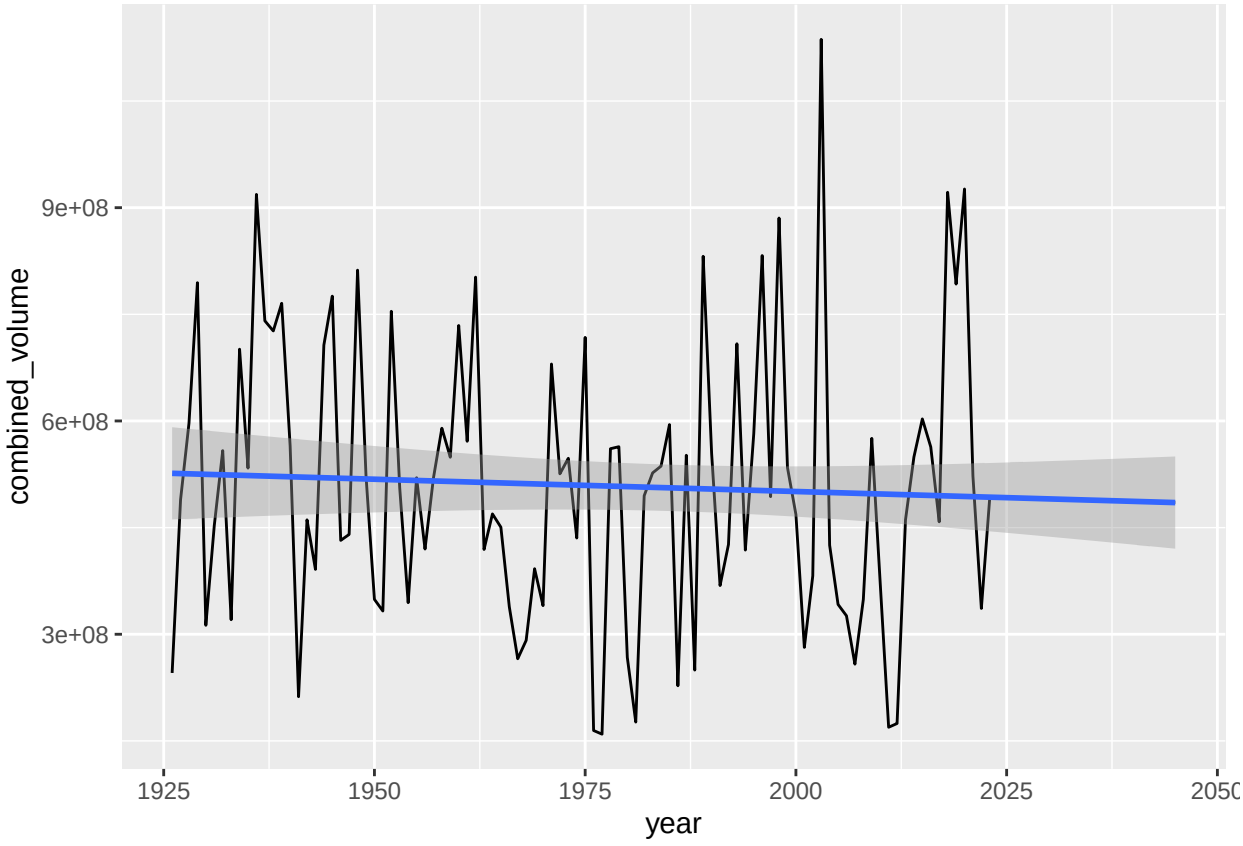

```
ggplot(data = combined, aes(x = year, y = recent_mean)) +
  geom_line() +
  geom_smooth(method = "lm") +
  xlim(1981, max(combined$recent_volume)) +
  geom_line(aes(color = year >= 2023)) +
  scale_color_manual(values = c("FALSE" = "black", "TRUE" = "red")) +
  scale_size_manual(values = c("FALSE" = 2, "TRUE" = 5)) +
  geom_vline(xintercept = 2023, linetype = "dashed", color = "red") +
  theme_minimal()
```

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

## Warning: Removed 55 rows containing non-finite outside the scale range
## (`stat_smooth()`).

## Warning: No shared levels found between `names(values)` of the manual scale and the
## data's size values.

## Warning: Removed 55 rows containing missing values or values outside the scale range
## (`geom_line()`).
## Removed 55 rows containing missing values or values outside the scale range
## (`geom_line()`).
```




```
ggplot(data = combined, aes(x = year, y = combined_volume)) +
  geom_line() +
  geom_smooth(method = "lm")
```

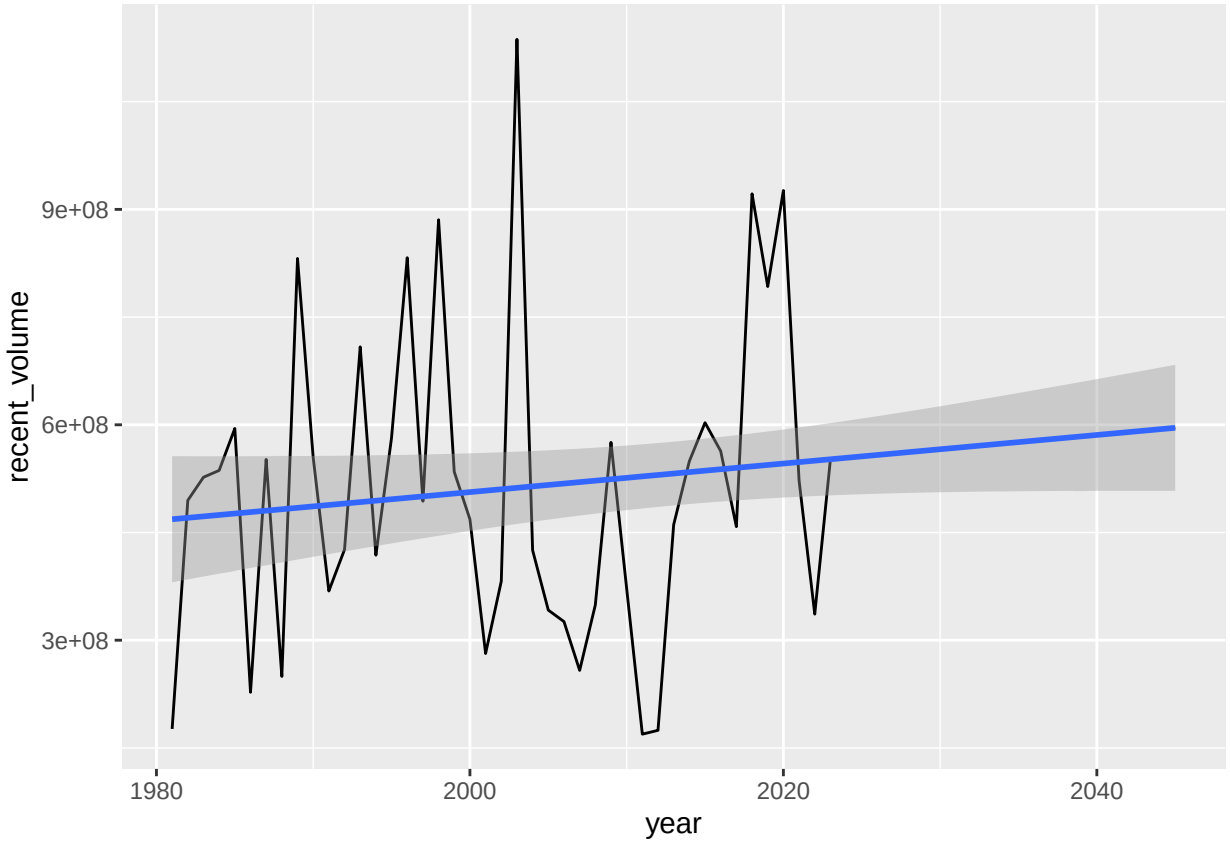
```
## `geom_smooth()` using formula = 'y ~ x'
```




```
ggplot(data = combined, aes(x = year, y = recent_volume)) +
  geom_line() +
  geom_smooth(method = "lm") +
  xlim(1981, max(combined$recent_volume))
```

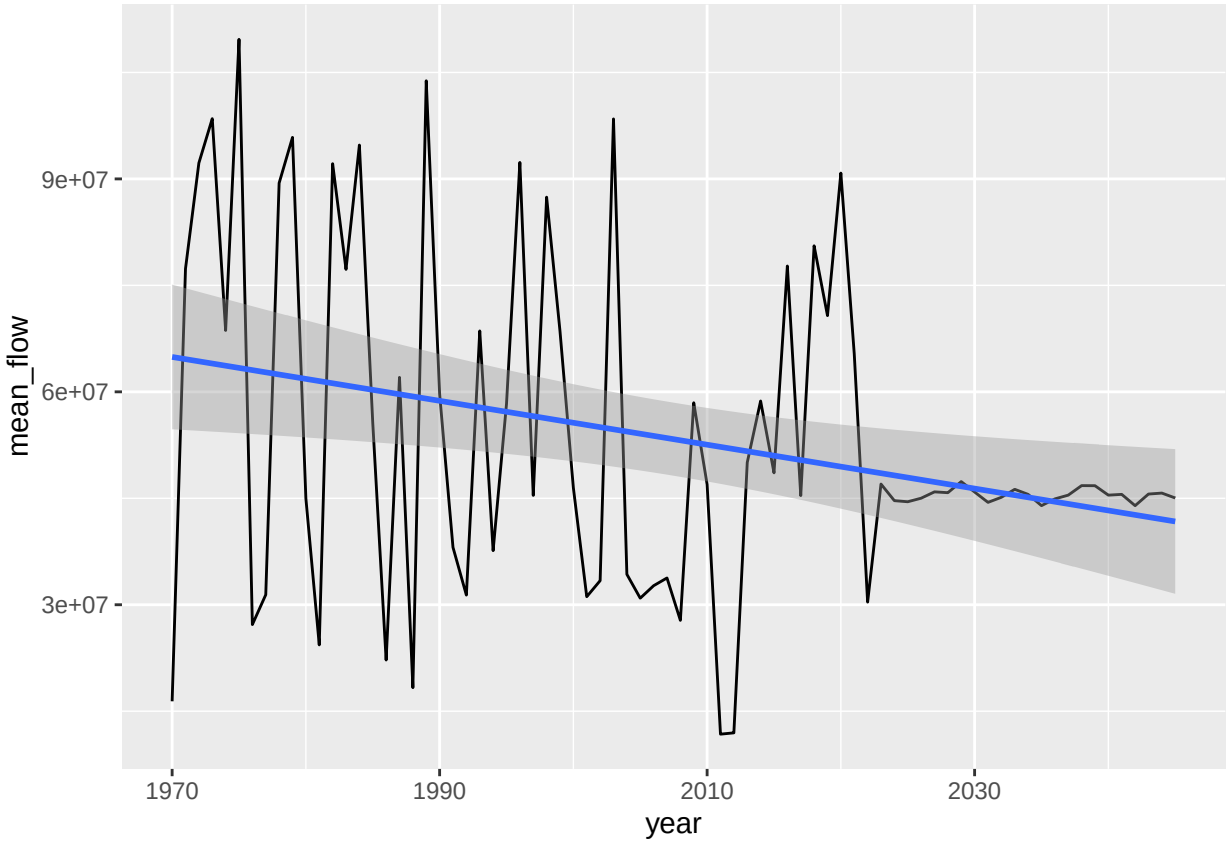
```
## `geom_smooth()` using formula = 'y ~ x'
```

```
## Warning: Removed 55 rows containing non-finite outside the scale range
## (`stat_smooth()`).
## Removed 55 rows containing missing values or values outside the scale range
## (`geom_line()`).
```



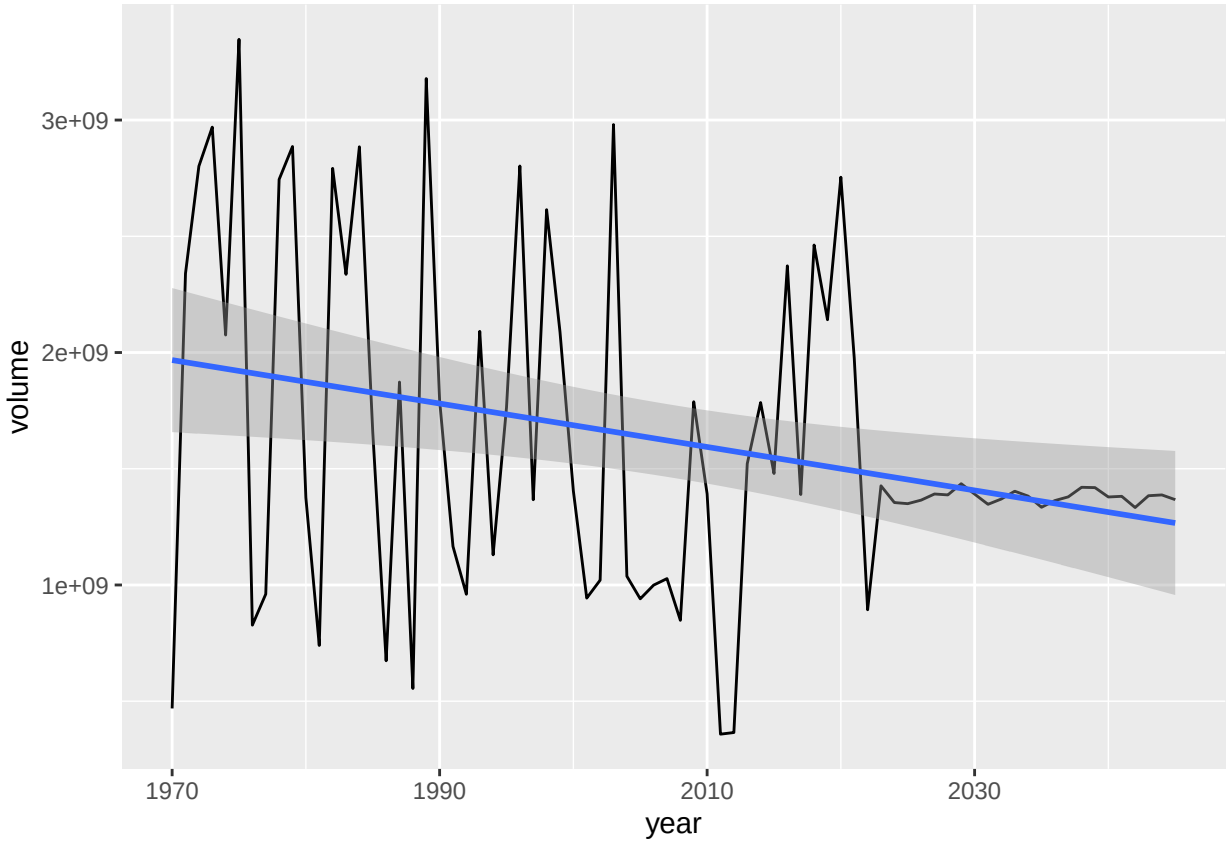

```
neuse <- read_xlsx("./Data Raw/neuse_projected.xlsx")
ggplot(data = neuse, aes(x = year, y = mean_flow)) +
  geom_line() +
  geom_smooth(method = "lm")
```

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




```
ggplot(data = neuse, aes(x = year, y = volume)) +
  geom_line() +
  geom_smooth(method = "lm")
```

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


3e+09
2e+09
1e+09
volume
1970
1990
2010
2030
year