# Project: Spatial and Temporal Analysis of Forest Fires in Turkey (2000-2024)

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Introduction In this project, I analyzed forest fire incidents in Turkey using NASA FIRMS satellite data (2000-2021) and examined the primary causes and rehabilitation efforts based on OGM Activity Reports (2020-2024). The main objective is to visualize the spatial distribution of fires across provinces, understand seasonal trends, and evaluate post-fire recovery strategies.

```
library(tidyverse)
library(sf)
library(rnaturalearth)
library(rnaturalearthdata)
library(scales)

file_path <- "C:/Users/Arda/Desktop/assignment 8/2000-2021 SINGLE TURKEY FIRE_M-C61_214067.csv"
raw_data <- read.csv(file_path)

turkey_map <- ne_states(country = "turkey", returnclass = "sf") %>%
  select(name_tr = name, geometry)

fire_sf <- st_as_sf(raw_data, coords = c("longitude", "latitude"), crs = 4326)
fire_joined <- st_join(fire_sf, turkey_map)

fire_joined$acq_date <- as.Date(fire_joined$acq_date)
fire_joined$month <- format(fire_joined$acq_date, "%b")
fire_joined$year <- as.numeric(format(fire_joined$acq_date, "%Y"))
fire_joined$month <- factor(fire_joined$month, levels = month.abb)
```

### 1. Spatial Distribution: Fires by Province

To identify the most vulnerable regions, I aggregated the fire incidents by province boundaries. The map below uses a categorized scale to highlight extreme outliers.

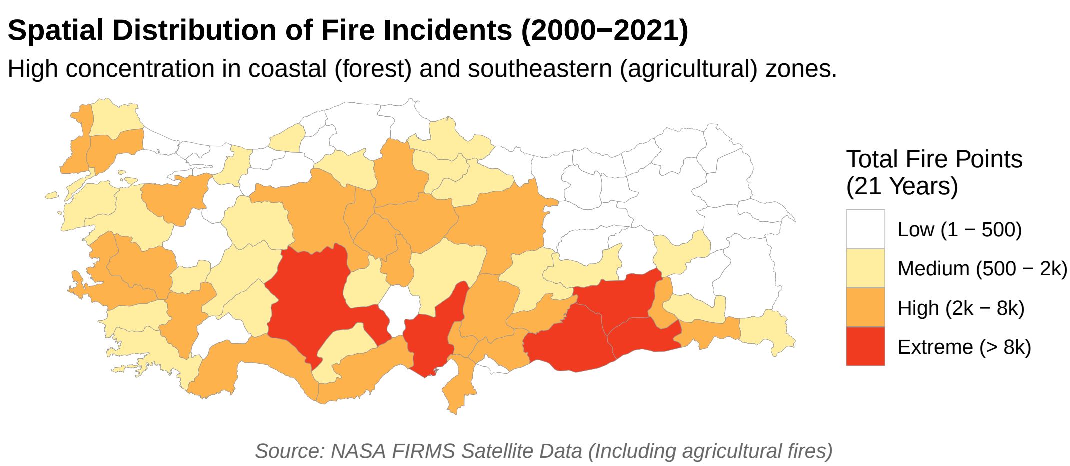
```
province_stats <- fire_joined %>%
  group_by(name_tr) %>%
  summarise(count = n()) %>%
  st_drop_geometry()

map_data_final <- left_join(turkey_map, province_stats, by = "name_tr")
map_data_final$count[is.na(map_data_final$count)] <- 0
```

```r
map_data_final$category <- cut(
  map_data_final$count,
  breaks = c(-1, 0, 500, 2000, 8000, 500000),
  labels = c("No Fire (0)",
             "Low (1 - 500)",
             "Medium (500 - 2k)",
             "High (2k - 8k)",
             "Extreme (> 8k)")
)

p1 <- ggplot(map_data_final) +
  geom_sf(aes(fill = category), color = "gray60", size = 0.1) +
  scale_fill_manual(
    values = c("white", "#ffeda0", "#feb24c", "#f03b20", "#800026"),
    name = "Total Fire Points\n(21 Years)"
  ) +
  labs(title = "Spatial Distribution of Fire Incidents (2000-2021)",
       subtitle = "High concentration in coastal (forest) and southeastern (agricultural) zones.",
       caption = "Source: NASA FIRMS Satellite Data (Including agricultural fires)") +
  theme_void() +
  theme(legend.position = "right",
        plot.title = element_text(face="bold"),
        plot.caption = element_text(color = "gray40", face = "italic"))

ggsave("Map.png", p1, width = 10, height = 6, dpi = 300)
p1
```




Analysis: The choropleth map reveals high fire activity in two distinct regions, categorized as "Extreme" (>8,000 points):

1- Mediterranean & Aegean Coasts: Provinces like Antalya, Muğla, and İzmir exhibit high fire counts primarily due to forest fires driven by the hot climate.

2-Southeastern Anatolia: Provinces like Adana and Şanlıurfa also appear in the highest category. This is largely attributed to intensive agricultural stubble burning, which satellite sensors detect as fire anomalies alongside forest incidents.

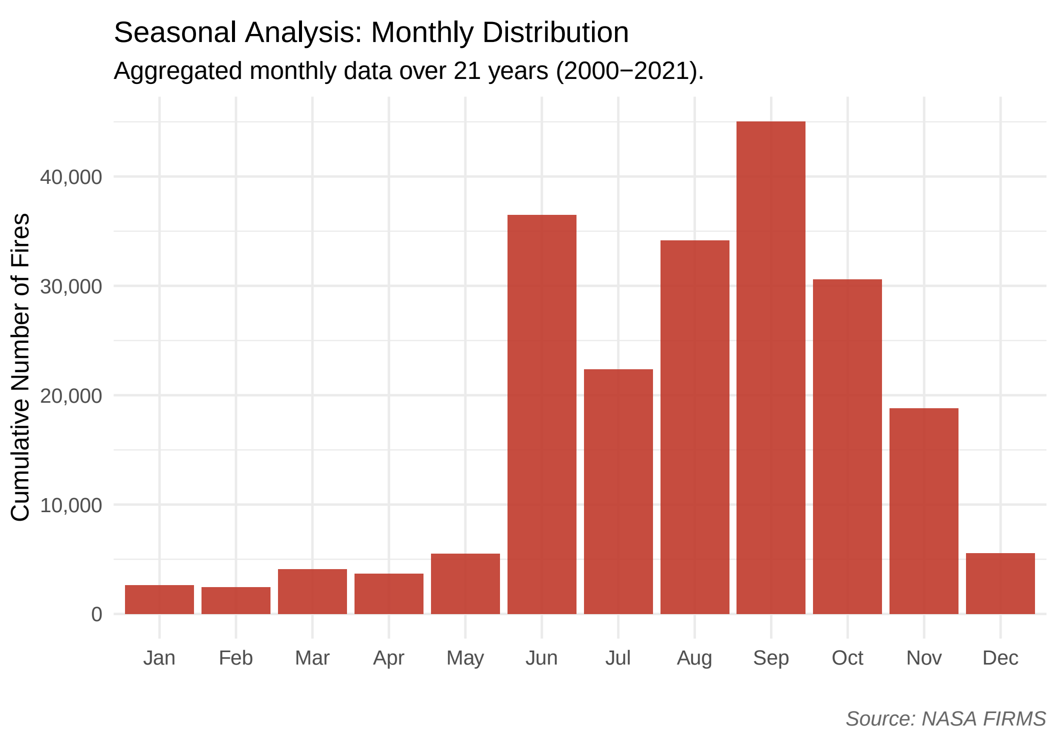
## 2. Seasonal Analysis

Understanding "when" fires occur is crucial for preparedness. I analyzed the monthly distribution of fire incidents to identify the peak fire season.

```
monthly_stats <- fire_joined %>%
  group_by(month) %>%
  summarise(count = n())

p2 <- ggplot(monthly_stats, aes(x = month, y = count)) +
  geom_col(fill = "#c0392b", alpha = 0.9) +
  scale_y_continuous(labels = comma) +
  labs(title = "Seasonal Analysis: Monthly Distribution",
       subtitle = "Aggregated monthly data over 21 years (2000-2021).",
       x = "", y = "Cumulative Number of Fires",
       caption = "Source: NASA FIRMS") +
  theme_minimal() +
  theme(plot.caption = element_text(color = "gray40", face = "italic"))

ggsave("Monthly.png", p2, width = 8, height = 5, dpi = 300)
p2
```



Analysis: This chart represents the cumulative sum of fire incidents for each month across the entire 21-year study period. By aggregating longitudinal data, the chart filters out year-to-year variations and reveals the region's permanent seasonal character. The data confirms a strict seasonal cycle where fire activity rises sharply in June and reaches its absolute peak in August and September.

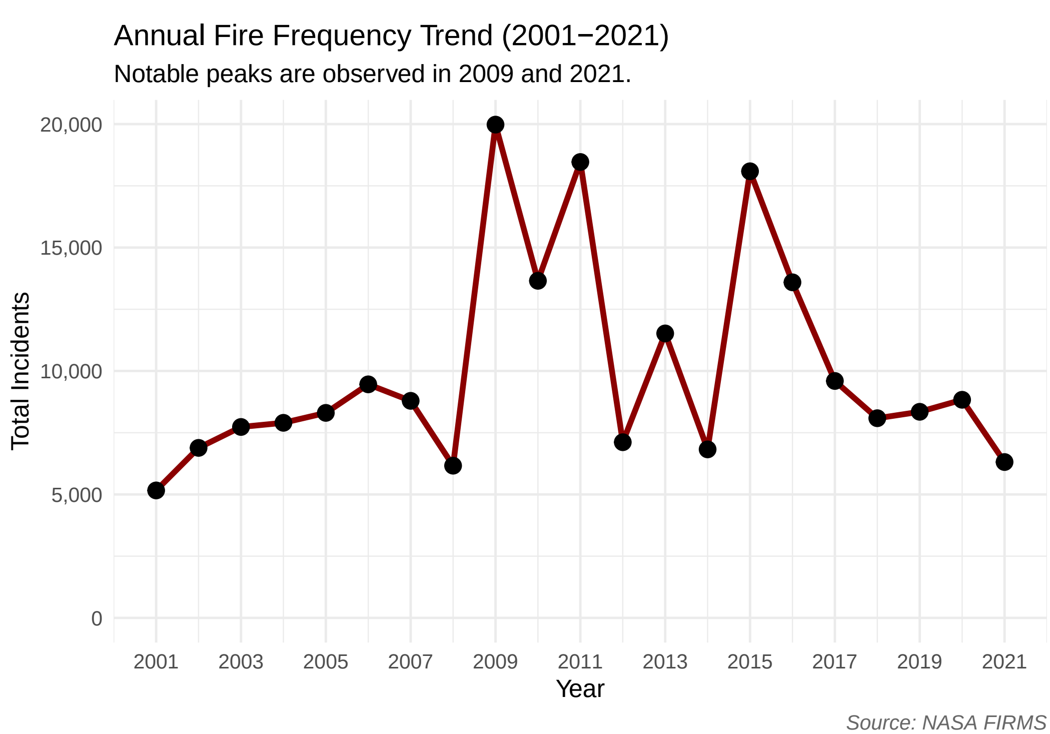
### 3. Annual Trend and Anomalies

I examined the yearly evolution of fire frequencies to detect any increasing trends or specific outlier years over the two-decade period. Note: Data for the year 2000 was excluded due to incomplete satellite coverage.

```r
yearly_stats <- fire_joined %>%
  filter(year > 2000) %>%
  group_by(year) %>%
  summarise(count = n())

p3 <- ggplot(yearly_stats, aes(x = year, y = count)) +
  geom_line(color = "darkred", size = 1.2) +
  geom_point(size = 3, color = "black") +
  scale_x_continuous(breaks = seq(2001, 2021, 2)) +
  scale_y_continuous(labels = comma, limits = c(0, NA)) +
  labs(title = "Annual Fire Frequency Trend (2001-2021)",
       subtitle = "Notable peaks are observed in 2009 and 2021.",
       x = "Year", y = "Total Incidents",
       caption = "Source: NASA FIRMS") +
  theme_minimal() +
  theme(plot.caption = element_text(color = "gray40", face = "italic"))

ggsave("Yearly.png", p3, width = 8, height = 5, dpi = 300)
p3
```



Analysis: The time-series reveals a fluctuating trend where the highest frequency of fire points was actually recorded in 2009, likely driven by widespread agricultural burning practices. While the 2021 spike is slightly lower in count, it corresponds to the catastrophic "mega-fires" that destroyed vast forest areas. This distinction highlights that satellite fire counts reflect the number of hotspots rather than the total area burned.

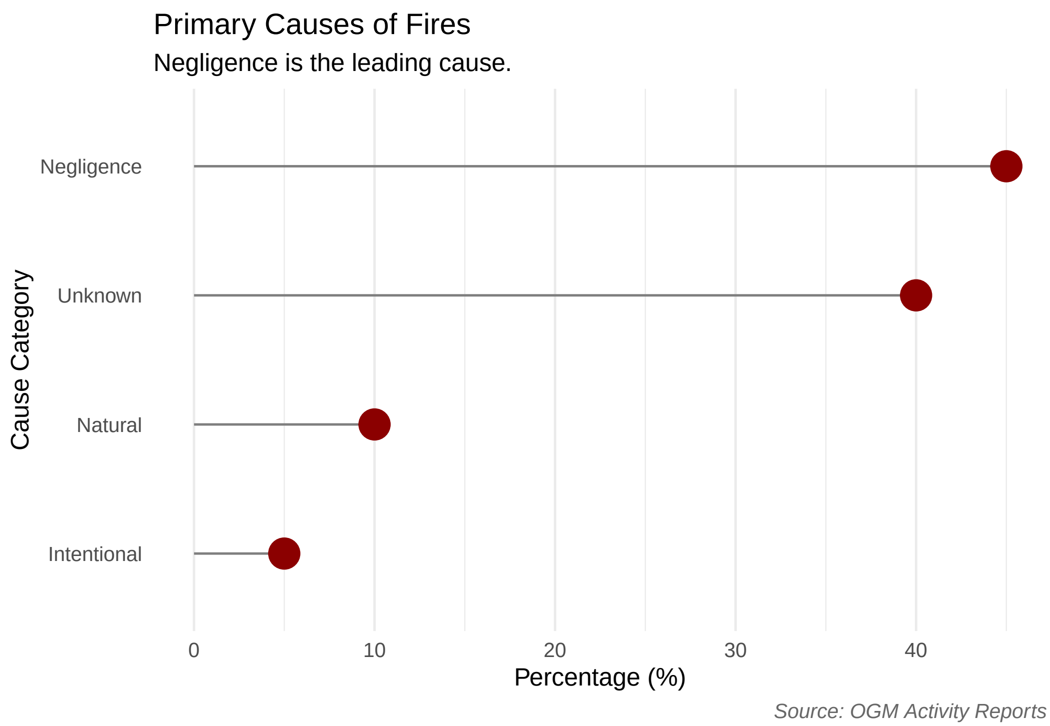
#### 4. Primary Causes of Fires

Using data from the General Directorate of Forestry (OGM), I visualized the primary causes of fires to understand the human factor.

```r
# Data from OGM Activity Reports (Representative)
df_causes <- data.frame(
  category = c("Negligence", "Unknown", "Natural", "Intentional"),
  count = c(45, 40, 10, 5)
)

p4 <- ggplot(df_causes, aes(x = reorder(category, count), y = count)) +
  geom_segment(aes(xend = reorder(category, count), y = 0, yend = count),
               color = "gray50") +
  geom_point(size = 6, color = "darkred") +
  coord_flip() +
  labs(title = "Primary Causes of Fires",
       subtitle = "Negligence is the leading cause.",
       x = "Cause Category", y = "Percentage (%)",
       caption = "Source: OGM Activity Reports") +
  theme_minimal() +
  theme(panel.grid.major.y = element_blank(),
        plot.caption = element_text(color = "gray40", face = "italic"))

ggsave("Lollipop.png", p4, width = 7, height = 5, dpi = 300)
p4
```




Analysis: The Lollipop chart clearly shows that Negligence (45%) is the leading cause of forest fires, far exceeding natural causes like lightning (10%). This implies that most fires are preventable through stricter public regulations.

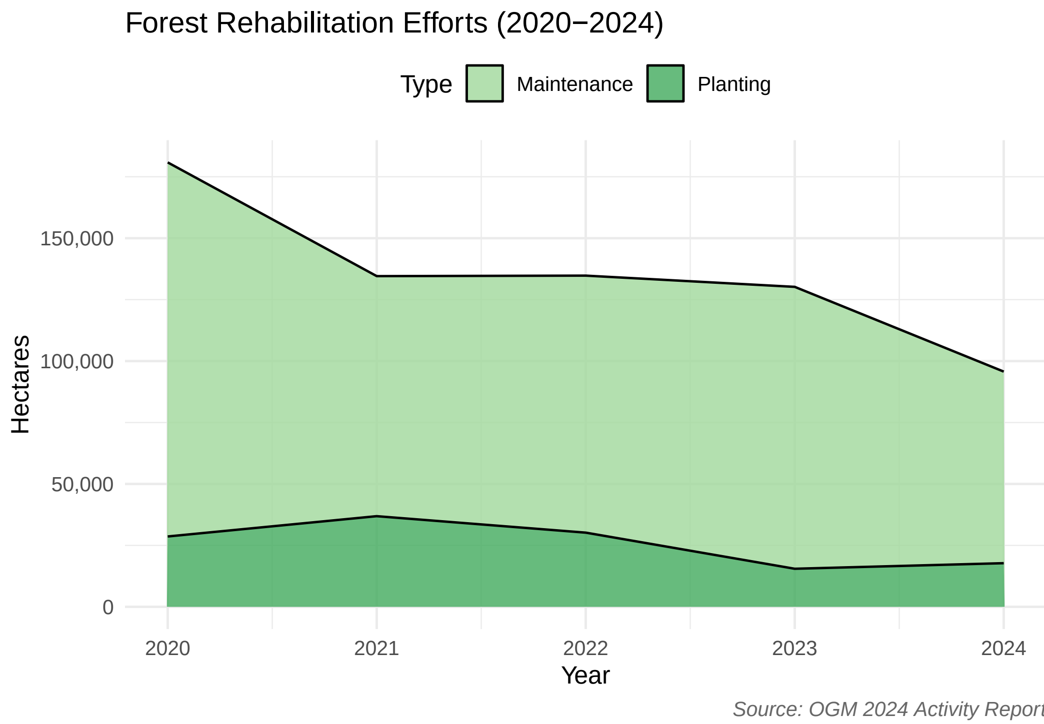
### 5. Rehabilitation Efforts (2020-2024)

Finally, I analyzed post-fire recovery data to compare new planting (afforestation) versus the maintenance of existing forests.

```r
# Data from OGM 2024 Activity Report
df_tree <- data.frame(
  year = c(2020, 2021, 2022, 2023, 2024),
  Planting = c(28632, 36886, 30183, 15488, 17759),
  Maintenance = c(152200, 97676, 104588, 114708, 77956)
) %>%
  pivot_longer(cols = c("Planting", "Maintenance"),
               names_to = "Type", values_to = "Hectares")

p5 <- ggplot(df_tree, aes(x = year, y = Hectares, fill = Type)) +
  geom_area(alpha = 0.8, color = "black") +
  scale_fill_manual(values = c("#a1d99b", "#41ab5d")) +
  scale_y_continuous(labels = comma) +
  labs(title = "Forest Rehabilitation Efforts (2020-2024)",
       caption = "Source: OGM 2024 Activity Report",
       x = "Year") +
  theme_minimal() +
  theme(legend.position = "top",
        plot.caption = element_text(color = "gray40", face = "italic"))
```

```r
ggsave("Afforestation.png", p5, width = 8, height = 5, dpi = 300)
p5
```




Analysis: The Area chart indicates that rehabilitation efforts focus heavily on the maintenance of existing areas rather than new planting. While new afforestation peaked in 2021 following the major fires, it has shown a declining trend, stabilizing around 17,000 hectares in 2024. Notably, the total volume of rehabilitation activity (combined area) shows a downward trend from 2020 to 2024.

Conclusion This study reveals that fire incidents in Turkey exhibit a dual character: forest fires concentrated in coastal Mediterranean zones and agricultural burning in Southeastern Anatolia. While the temporal analysis highlights 2021 as a catastrophic anomaly driven by climate factors, the prevalence of negligence (45%) indicates that human error remains the primary driver. Furthermore, recent data shows a strategic shift in rehabilitation efforts towards maintenance rather than new afforestation, with a noticeable decline in total activity volume since 2020. Future policies must address both public awareness for prevention and sustainable resource allocation for recovery.

Data Sources & References


NASA FIRMS: Fire Information for Resource Management System (FIRMS) [2000-2021]. Retrieved via Kaggle (NASA Earthdata). Used for spatial, seasonal, and annual analysis.

OGM (Orman Genel Müdürlüğü): 2024 Administrative Activity Report (2024 Faaliyet Raporu), Table 22 ("Ağaçlandırma Çalışmaları. . . "). Used for analyzing causes and rehabilitation efforts.