Homework 2: Redlining & Environmental Injustice

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```
# Load packages & set ggplot theme
library(tidyverse)
library(sf)
library(tmap)
library(kableExtra)
library(patchwork)
```

```
# Load data
ejscreen <- st_read(here::here('data', 'ejscreen', 'EJSCREEN_2023_BG_StatePct_with_AS_CNM

holc <- st_read(here::here('data','mapping-inequality' ,'mapping-inequality-los-angeles.j
  st_make_valid() # Make invalid geometries valid

birds <- st_read(here::here('data', 'gbif-birds-LA', 'gbif-birds-LA.shp'), quiet = TRUE)
```

```
# Filter ejscreen data to counties of interest for basemap
la_county <- ejscreen |>
  filter(CNTY_NAME %in% c("Los Angeles County", "Orange County", "San Bernardino County")
  filter(AREALAND != 0) |> # Exclude water bodies
  st_transform(crs = 4326) # Transform to EPSG:4326 crs
```

Part 1: Redlining & Environmental Justice

1.1 Map of HOLC redline grades

```
# Check for matching crs before mapping
if (st_crs(la_county) == st_crs(holc)){
  print('CRSs match')
} else {
  warning("CRSs don't match")
}
```

```
[1] "CRSs match"
```

```
# Create custom color list for plots
colors <- c("#90be6d", "#277da1", "#f9c74f", "#f94144")
```

```
# Plot distribution of HOLC grades across LA county
tm_shape(la_county, bbox = st_bbox(holc)) +
```

```
    tm_fill(fill = "grey40", col = "grey40") +
 tm_shape(holc) +
    tm_fill(fill = 'grade',
            fill.scale = tm_scale(values = colors),
            fill.legend = tm_legend(title = "Grade", position = c("top", "right"), height =
 tm_title(text = "HOLC Grades Across LA County") +
 tm_compass(type = "4star", position = c("bottom", "right"), size = 5) +
 tm_scalebar(position = c("bottom", "right"), text.size = 0.9) +
 tm_layout(bg.color = "#78d5d7")
```

HOLC Grades Across LA County
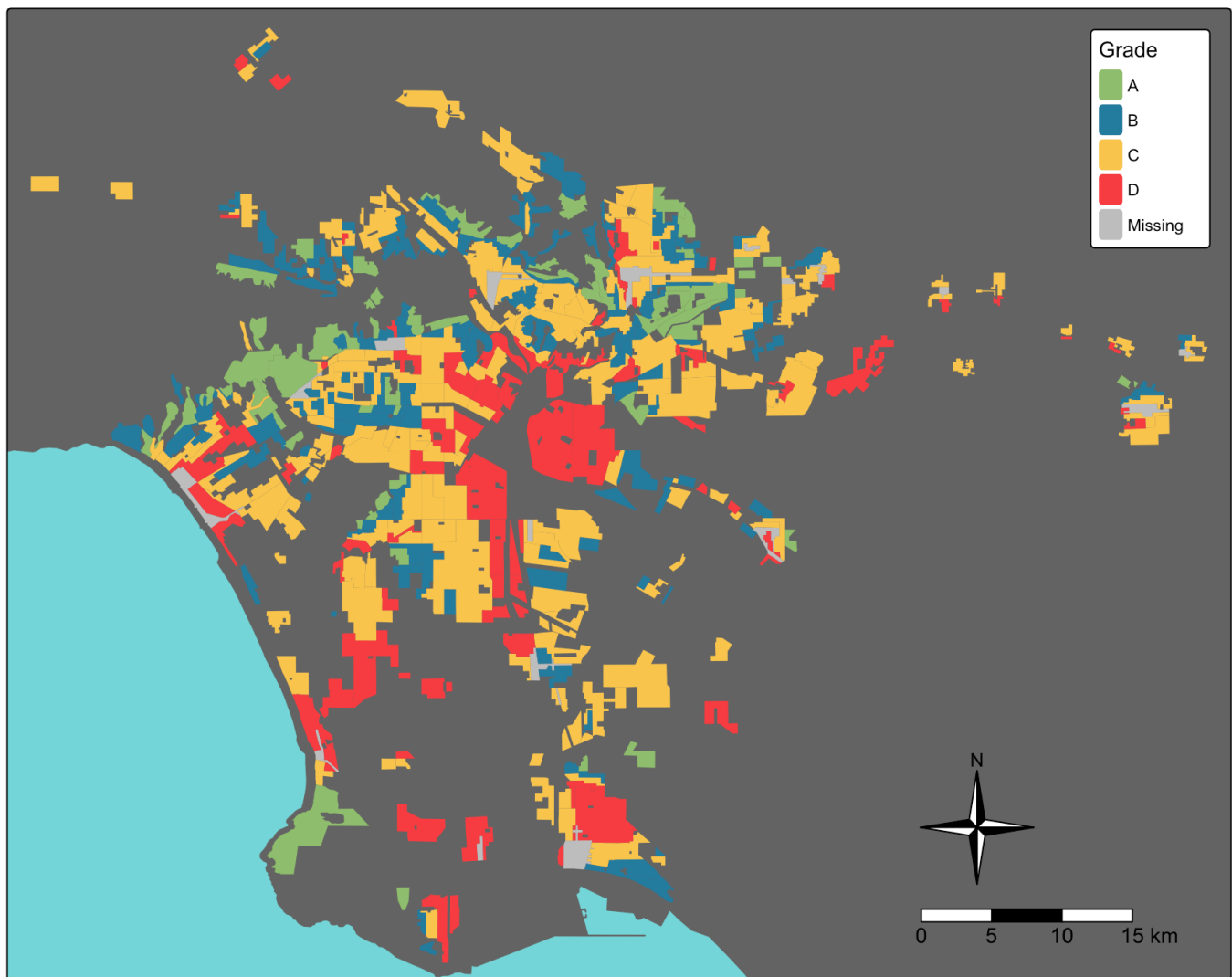
1.2 Table of Percentage of Census block group in each HOLC grade

```
# Join holc & la_county dfs
combined_la_holc <- st_join(x = holc, y = la_county) |>
  st_drop_geometry() # Drop geometries

# Group & create holc summary statistics
grade_percent_df <- combined_la_holc |>
  group_by(grade) |>
  summarise(count = n()) |>
  mutate(grade_percentage = round(x = (count / sum(count)) * 100, digits = 2)) |>
  ungroup()

# Display table
kable(grade_percent_df,
      col.names = c("Grade", "Count", "Percentage (%)"),
      caption = "Table 1. Percentage of Census Block Groups by HOLC Grade")
```

Table 1. Percentage of Census Block Groups by HOLC Grade

Grade	Count	Percentage (%)
A	449	7.03
B	1239	19.40
C	3058	47.87
D	1346	21.07
NA	296	4.63

1.3 HOLC grades visuals

Barplots

```
# Group & create ejscreen summary statistics
ej_conditions_df <- combined_la_holc |>
  group_by(grade) |>
  summarise(lowincpct_mean = mean(LOWINCPCT) * 100,
            p_pm25_mean = mean(P_PM25),
            p_lifeexppct_mean = mean(P_LIFEEXPPCT, na.rm = TRUE))
```

```
# Create low-income percentage plot
lowinc <- ej_conditions_df |>
  ggplot(aes(x = grade, y = lowincpct_mean, fill = grade)) +
  scale_fill_manual(values = colors, na.value = 'grey59') +
  geom_bar(stat = 'identity', show.legend = FALSE) +
  labs(x = "Grade",
       y = "Percent Low Income Mean (%)",
       tag = "A")
```

```r
# Create pm2.5 plot
pm25 <- ej_conditions_df |>
  ggplot(aes(x = grade, y = p_pm25_mean, fill = grade)) +
  scale_fill_manual(values = colors, na.value = 'grey59') +
  geom_bar(stat = 'identity', show.legend = FALSE) +
  labs(x = "Grade",
       y = "Percentile PM2.5 Mean",
       tag = "B")

# Create life expectancy plot
life_ex <- ej_conditions_df |>
  ggplot(aes(x = grade, y = p_lifeexppct_mean, fill = grade)) +
  scale_fill_manual(values = colors, na.value = 'grey59') +
  geom_bar(stat = 'identity', show.legend = FALSE) +
  labs(x = "Grade",
       y = "Percentile Low Life Expectancy Mean",
       tag = "C")

# Patchwork together
lowinc / (pm25 + life_ex)  + plot_annotation(title = "Figure 1.3.1. EJScreen Metrics — Co
```

Figure 1.3.1. EJScreen Metrics - Comparisons by HOLC Grade

A

B

C
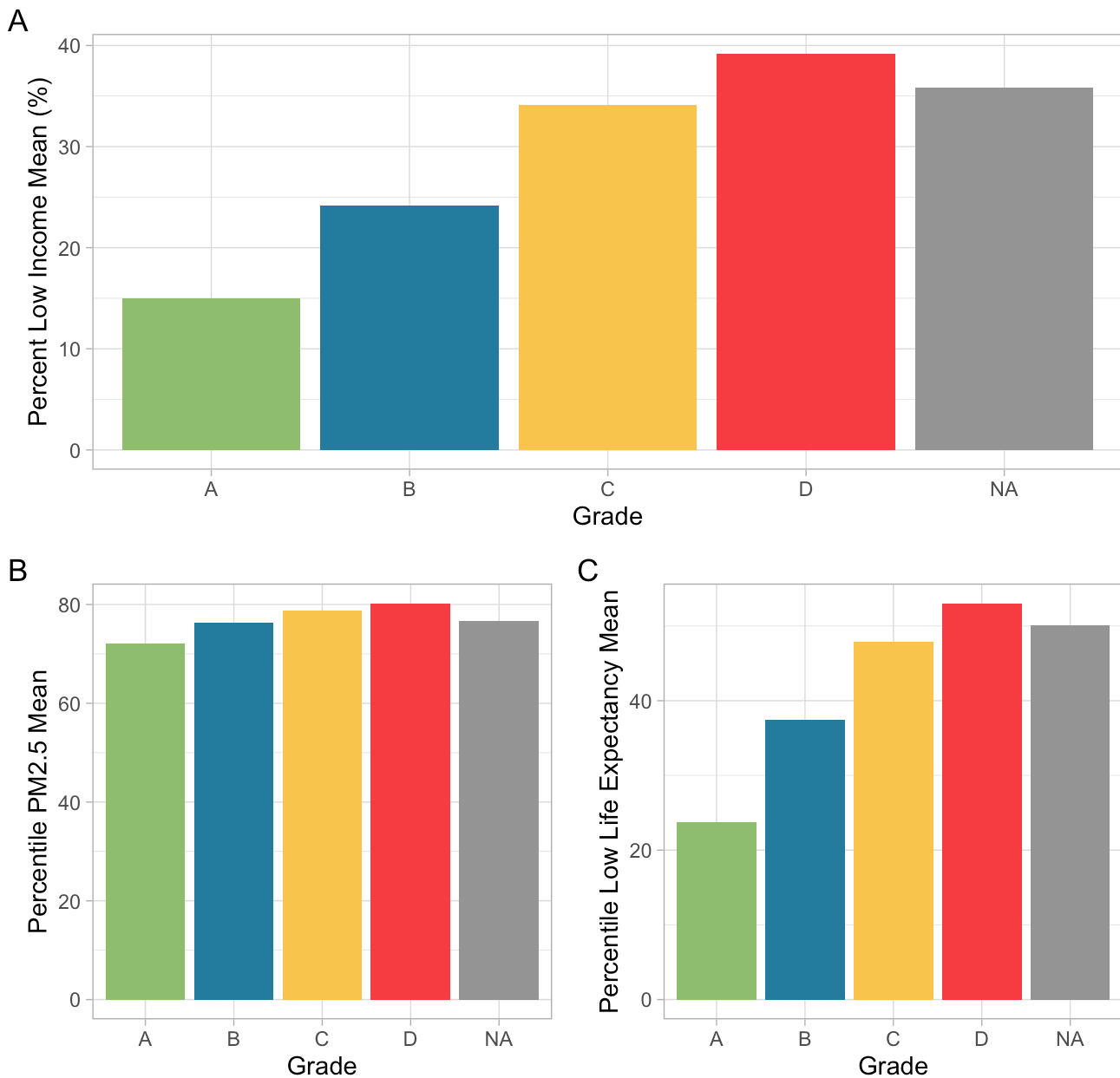
Spatially related maps

```
# Join holc & ejscreen LA but keep geometries
la_holc_geoms <- st_join(x = holc, y = la_county)

# Confirm class
class(la_holc_geoms)
```

```
[1] "sf"         "data.frame"
```

```
# Grades map
grades_map <- tm_shape(la_county, bbox = st_bbox(holc)) +
```

```r
    tm_fill(fill = "grey40", col = "grey40") +
tm_shape(holc) +
  tm_fill(fill = 'grade',
          fill.scale = tm_scale(values = 'brewer.yl_or_rd'),
          fill.legend = tm_legend(title = "Grade",
                                  text.size = 0.9,
                                  width = 8,
                                  height = 12)) +
  tm_layout(legend.position = c("right", "bottom")) +
  tm_compass(position = c("right", "top")) +
  tm_scalebar(position = c(0.6, 0.95), text.size = 0.75) +
  tm_title(text = "Figure 1.3.2. EJScreen Metrics – Spatial Comparison")

# Percent low income map
lowinc_map <- tm_shape(la_county, bbox = st_bbox(holc)) +
  tm_fill(fill = "grey40", col = "grey40") +
tm_shape(la_holc_geoms) +
  tm_fill(fill = "LOWINCPCT",
          fill.scale = tm_scale_continuous(values = 'brewer.yl_or_rd'),
          fill.legend = tm_legend(title = "Percent Low Income",
                                  reverse = TRUE,
                                  labels = c("100%", "80%", "60%", "40%", "20%", "0%"),
                                  height = 16)) +
  tm_layout(legend.position = c("right", "bottom"),
            inner.margins = c(0.05, 0, 0, 0)) +
  tm_title(text = " ")

# Percentile PM2.5 map
pm25_map <- tm_shape(la_county, bbox = st_bbox(holc)) +
  tm_fill(fill = "grey40", col = "grey40") +
tm_shape(la_holc_geoms) +
  tm_fill(fill = "P_PM25",
          fill.scale = tm_scale(values = 'brewer.yl_or_rd'),
          fill.legend = tm_legend(title = "PM2.5 Percentile",
                                  reverse = TRUE,
                                  text.size = 0.8)) +
  tm_layout(legend.position = c("right", "bottom"))

# Percentile low life expectancy map
life_ex_map <- tm_shape(la_county, bbox = st_bbox(holc)) +
  tm_fill(fill = "grey40", col = "grey40") +
tm_shape(la_holc_geoms) +
  tm_fill(fill = "P_LIFEEXPPCT",
          fill.scale = tm_scale(values = 'brewer.yl_or_rd'),
          fill.legend = tm_legend(title = "Low Life Expentancy\nPercentile",
                                  reverse = TRUE,
                                  width = 11, height = 13)) +
  tm_layout(legend.position = c("right", "bottom"))
```
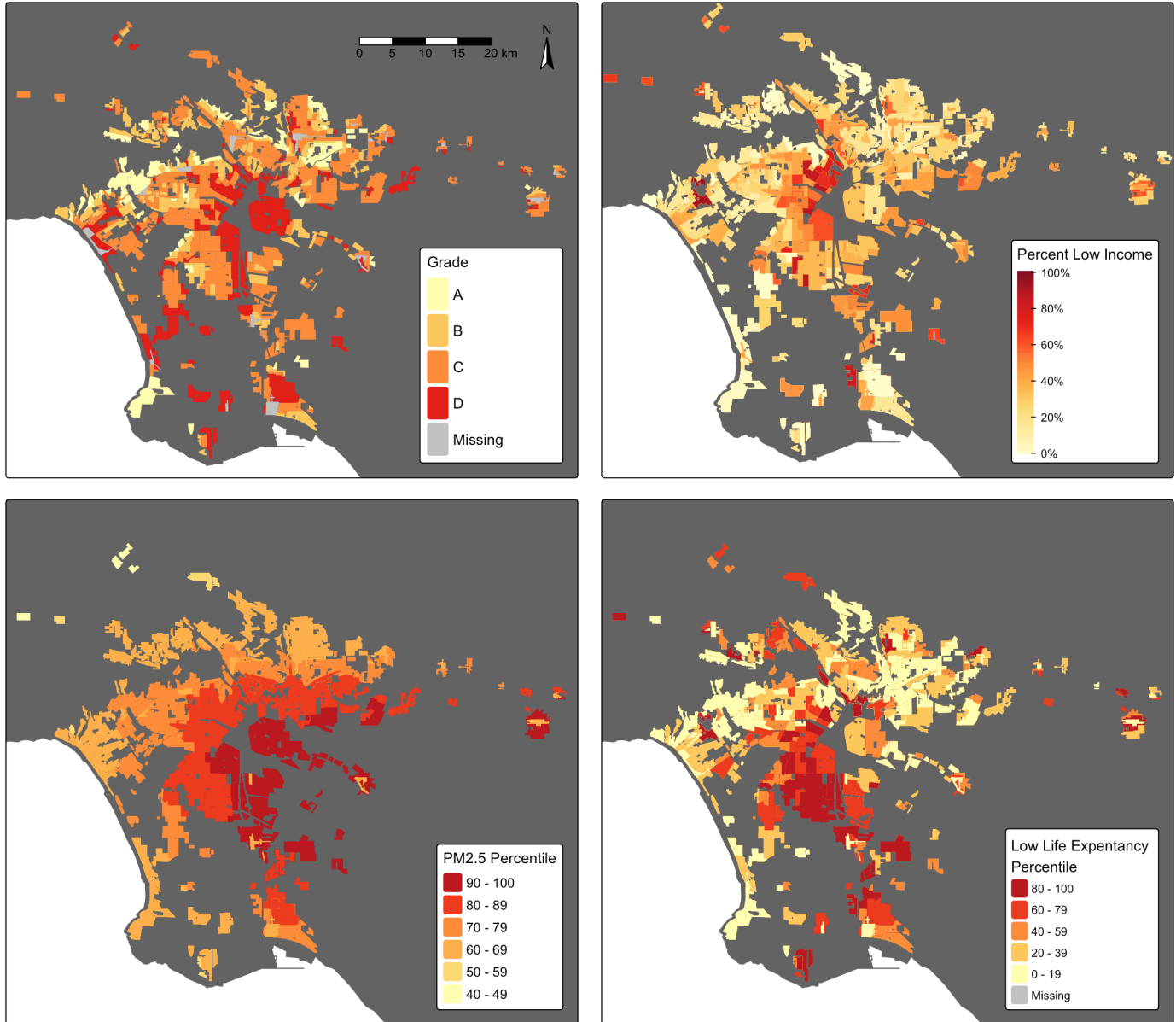
```
# Combine maps
tmap_arrange(grades_map, lowinc_map, pm25_map, life_ex_map, nrow = 2)
```

Figure 1.3.2. EJScreen Metrics - Spatial Comparison

1.4 Summary

Comparing the means of all three variables of interest (Figure 1.3.1): 1. percent low income (A) 2. PM2.5 percentile (B) 3. low life expectancy percentile (C), shows a clear relationship with HOLC grade. Grade A has the lowest mean for all three variables. On the other hand, Grade D has the highest means, with a sequential increase by grade in-between Grades A-D. The four maps (Figure 1.3.2), compare the same three variables and show the spatial distribution across LA. Neighborhoods with worse HOLC grades tend to have higher percentage of low income populations. Additionally, these neighborhoods have higher percentiles for PM2.5 and low life expectancy, indicating worse air quality and shorter life expectancy compared to the rest of California State. These relationships show that historically redlined

neighborhoods face greater environmental burdens and disproportionate health disparities compared to locations with a higher HOLC grade.

Part 2: Redlining & Bird Observations

2.1 Bird Observations per HOLC grade

```r
# Check for matching crs for joining
if (st_crs(holc) == st_crs(birds)){
  print('CRSs match')
} else {
  warning("CRSs don't match")
}
```

```
[1] "CRSs match"
```

```r
# Spatially join holc & birds df
holc_birds <- st_join(holc, birds)
```

```r
# Create dataframe of birds summary statistics
bird_percent_df <- holc_birds |>
  group_by(grade) |>
  summarise(bird_obs_count = n()) |>
  mutate(bird_obs_perc = (bird_obs_count / sum(bird_obs_count)) * 100) |>
  st_drop_geometry()
```

```r
# Create barplot of bird observations percent by grade
ggplot(bird_percent_df, aes(x = grade, y = bird_obs_perc, fill = grade)) +
  scale_fill_manual(values = colors, na.value = 'grey59') +
  geom_bar(stat = 'identity', show.legend = FALSE) +
  labs(title = "Figure 2.1. Percentage of Total Bird Observations by Grade",
       x = "Grade",
       y = "Percentage (%)") +
  theme_light()
```

Figure 2.1. Percentage of Total Bird Observations by Grade
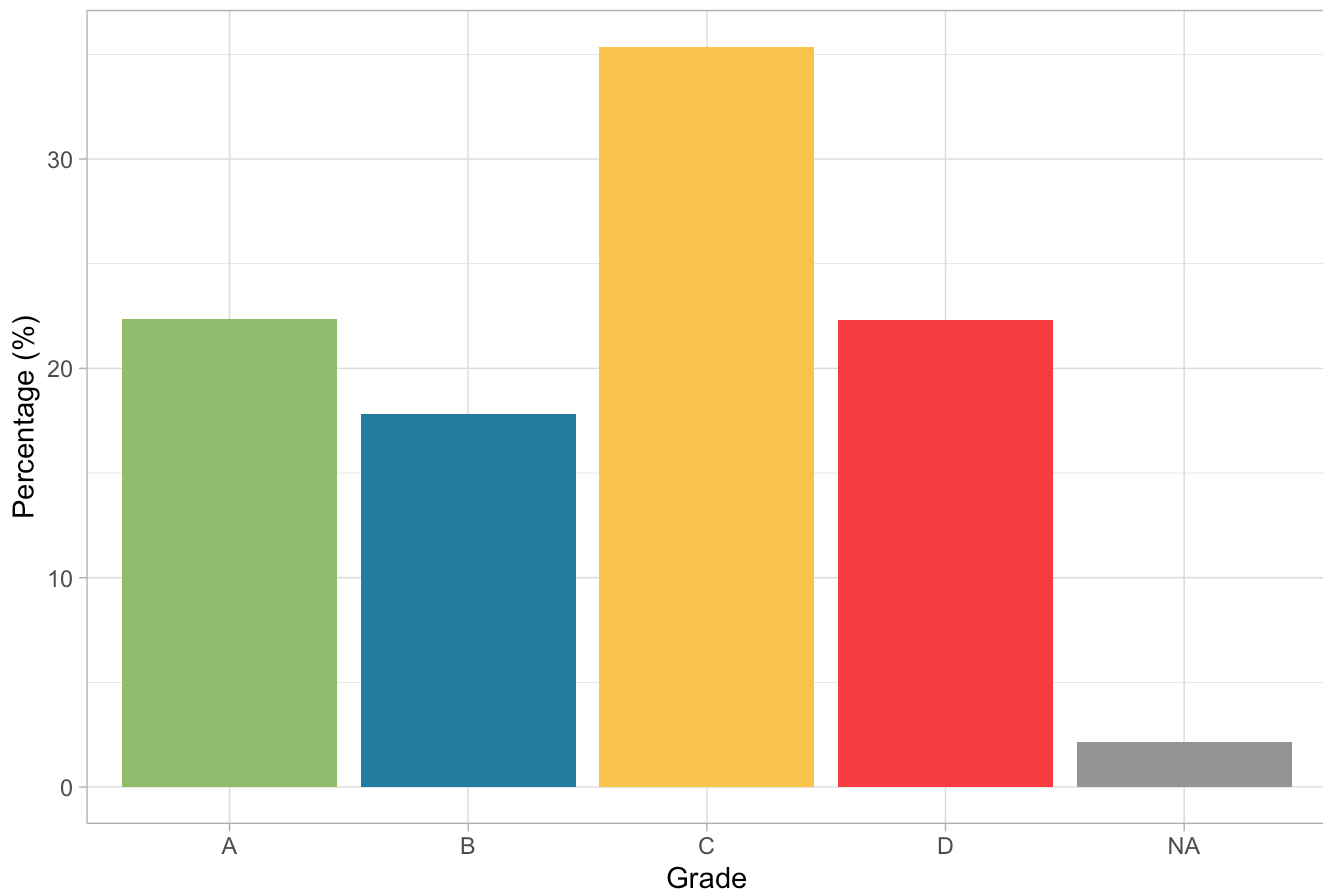
2.2 Summary

Figure 2 shows that Grade C locations contain the most bird observations by percentage. However, the results of Ellis-Soto et al. 2023 show that locations with a Grade A rating have the highest number of bird observations per kilometer squared when accounting for sampling density. In the methods section of Ellis-Soto et al. 2023, it is stated that the total area of each HOLC grade was calculated and then used to calculate how bird observations differed across grades. Without considering the amount of total area for each grade, grades that cover more area (Grade C) would appear to have the majority of bird observations. Factoring in sample density per area adjusts observation counts relative to area so that larger areas don't disproportionately affect the results.

```
area_holc_birds <- holc_birds|>
  group_by(grade) |>
  summarise(total_area_km2 = as.numeric(sum(unique(st_area(geometry)) / 1e6))) |>
  st_drop_geometry()

ggplot(data = area_holc_birds, aes(grade, total_area_km2, fill = grade)) +
  scale_fill_manual(values = colors, na.value = 'grey59') +
  labs(x = "Grade", y = "Total Area (square kilometers)", title = "Figure 2.2. Total Area
  geom_bar(stat = "identity", show.legend = FALSE) +
  theme_light()
```

Figure 2.2. Total Area by Grade
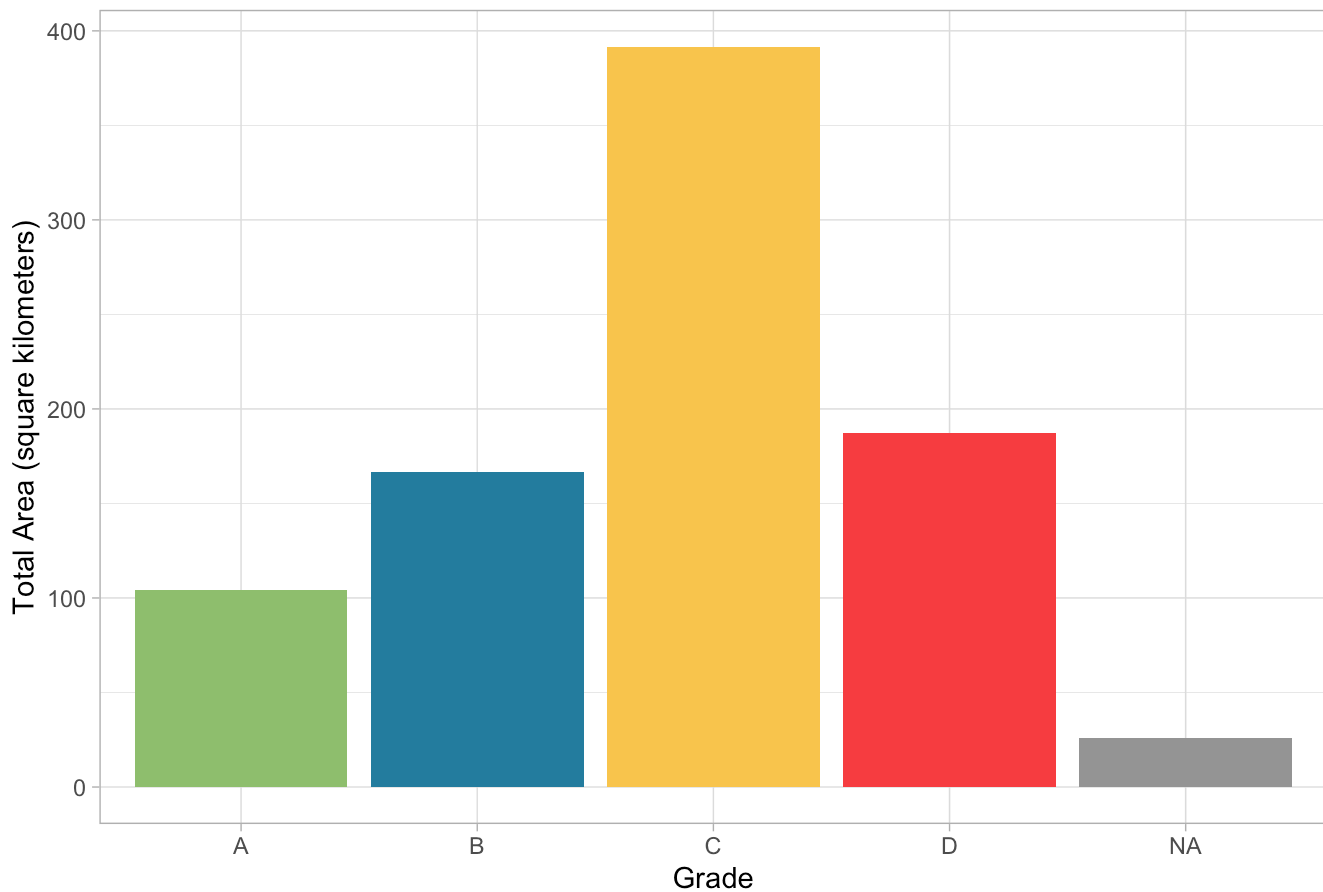
References

- United States Environmental Protection Agency, 2025. EJSCREEN. Retrieved: October 16, 2025, from (https://19january2021snapshot.epa.gov/ejscreen.html).

- Nelson, Robert K., LaDale Winling, et al. "Mapping Inequality: Redlining in New Deal America." Edited by Robert K. Nelson. American Panorama: An Atlas of United States History, 2023. Retrieved: October 16, 2025 from (https://dsl.richmond.edu/panorama/redlining)

- Global Biodiversity Information Facility, 2021. GBIF. Retrieved: October 16, 2025 from (https://www.gbif.org/)