

Data cleaning for Exploratory Data Analysis Eastern Bluebird

Capstone

Team: Yichen Le yl4347, Yuheng Shen ys2393, Linyi Xia lx277, Jia Liu jl4769, Rongjian Zhai rz495

Domain problem formulation

We aim to build a robust workflow that predicts Eastern Bluebird occurrences across their range in the eastern United States and southern Canada. The predictors appear to come from gridded environmental products summarizing land cover composition and topography. There is no accompanying metadata, so part of the project involves confirming how these variables were constructed (e.g., spatial resolution, temporal coverage, buffer size). Understanding the provenance of each variable is essential before interpreting model results or making ecological claims.

Step 1: Review background information

Information on data collection

The source file is distributed as `EasternBluebird.csv`, a comma-separated export from an unknown system. No formal documentation accompanied the file. Key open questions:

- Who produced the CSV export and at what stage of processing (raw observations, processed grids, etc.)?
- Do the land cover percentages represent a single year, a multi-year average, or multiple concentric buffers stacked together (totals sometimes exceed 100%)?
- Are repeated latitude/longitude pairs distinct surveys through time or different subsamples of the same remote-sensing grid?

Data dictionary

Column descriptions below are inferred from header names and exploratory analysis. They should be verified against official documentation when it becomes available.

```
data_dictionary <- data.frame(
  column = c(
    "LATITUDE", "LONGITUDE", "ELEV", "Shallow_Ocean", "CoastShore_lines",
    "Shallow_Inland", "Deep_Inland", "Moderate_Ocean", "Deep_Ocean",
    "Evergreen_needle", "Grasslands", "Croplands", "Urban_Built", "Barren",
    "Evergreen_broad", "Deciduous_needle", "Deciduous_broad", "Mixed_forest",
    "Closed_shrubland", "Open_shrubland", "Woody_savannas", "Savannas", "y"
  ),
  description = c(
    "Latitude of the sampling footprint in decimal degrees (WGS84).",
    "Longitude of the sampling footprint in decimal degrees (WGS84, negative for West).",
    "Elevation of the footprint in meters above sea level (negative values indicate locations below sea level).",
    "Percent of the footprint classified as shallow ocean water.",
    "Percent of the footprint flagged as coastal shoreline interface.",
    "Percent of the footprint covered by shallow inland water bodies.",
    "Percent of the footprint covered by deep inland water bodies.",
  )
)
```

```

    "Percent of the footprint in moderate-depth ocean water.",
    "Percent of the footprint in deep ocean water.",
    "Percent evergreen needleleaf forest cover.",
    "Percent grassland cover.",
    "Percent cropland or agricultural cover.",
    "Percent urban or built-up land cover.",
    "Percent barren land (bare soil/rock).",
    "Percent evergreen broadleaf forest cover.",
    "Percent deciduous needleleaf forest cover.",
    "Percent deciduous broadleaf forest cover.",
    "Percent mixed forest cover.",
    "Percent closed shrubland cover.",
    "Percent open shrubland cover.",
    "Percent woody savanna cover.",
    "Percent savanna cover.",
    "Binary indicator of Eastern Bluebird presence (1) or absence (0) for this footprint."
  ),
  stringsAsFactors = FALSE
)

knitr::kable(data_dictionary)

```

column	description
LATITUDE	Latitude of the sampling footprint in decimal degrees (WGS84).
LONGITUDE	Longitude of the sampling footprint in decimal degrees (WGS84, negative for West).
ELEV	Elevation of the footprint in meters above sea level (negative values indicate locations below sea level).
Shallow_Ocean	Percent of the footprint classified as shallow ocean water.
CoastShore_lines	Percent of the footprint flagged as coastal shoreline interface.
Shallow_Inland	Percent of the footprint covered by shallow inland water bodies.
Deep_Inland	Percent of the footprint covered by deep inland water bodies.
Moderate_Ocean	Percent of the footprint in moderate-depth ocean water.
Deep_Ocean	Percent of the footprint in deep ocean water.
Evergreen_needle	Percent evergreen needleleaf forest cover.
Grasslands	Percent grassland cover.
Croplands	Percent cropland or agricultural cover.
Urban_Built	Percent urban or built-up land cover.
Barren	Percent barren land (bare soil/rock).
Evergreen_broad	Percent evergreen broadleaf forest cover.
Deciduous_needle	Percent deciduous needleleaf forest cover.
Deciduous_broad	Percent deciduous broadleaf forest cover.
Mixed_forest	Percent mixed forest cover.
Closed_shrubland	Percent closed shrubland cover.
Open_shrubland	Percent open shrubland cover.
Woody_savannas	Percent woody savanna cover.
Savannas	Percent savanna cover.
y	Binary indicator of Eastern Bluebird presence (1) or absence (0) for this footprint.

Step 2: Load the data

We load the CSV with base R's `read.csv` and convert key columns to numeric so later steps are straightforward.

```

options(stringsAsFactors = FALSE)

data_path <- "EasternBluebird.csv"
file_details <- file.info(data_path)
file_overview <- data.frame(
  file_size_mb = round(file_details$size / 1024^2, 2),
  last_modified = file_details$mtime
)
file_overview

##   file_size_mb      last_modified
## 1         7.26 2025-10-31 15:42:33

bluebird_raw <- read.csv(data_path, stringsAsFactors = FALSE)
str(bluebird_raw)

## 'data.frame':    64724 obs. of  23 variables:
##  $ LATITUDE      : num  35.3 36 36.7 37 37.3 ...
##  $ LONGITUDE     : num  -76.6 -78.9 -81.5 -79.5 -80.5 ...
##  $ ELEV          : num  2.24 100.92 939.3 212.17 773.58 ...
##  $ Shallow_Ocean : num  0 0 0 0 0 ...
##  $ CoastShore_lines: num  0 0 0 0 0 ...
##  $ Shallow_Inland : num  0 0 0 0 0 ...
##  $ Deep_Inland    : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ Moderate_Ocean : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ Deep_Ocean     : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ Evergreen_needle: num  40.82 0 0 2.04 0 ...
##  $ Grasslands     : num  2.04 0 0 0 0 ...
##  $ Croplands      : num  0 0 0 0 0 ...
##  $ Urban_Built    : num  0 63.9 0 0 0 ...
##  $ Barren         : num  0 0 0 0 0 ...
##  $ Evergreen_broad : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ Deciduous_needle: num  0 0 0 0 0 ...
##  $ Deciduous_broad : num  0 0 100 10.2 100 ...
##  $ Mixed_forest   : num  51 11.1 0 85.7 0 ...
##  $ Closed_shrubland: num  0 0 0 0 0 0 0 0 0 0 ...
##  $ Open_shrubland : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ Woody_savannas : num  4.08 25 0 2.04 0 ...
##  $ Savannas       : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ y              : int  0 0 0 0 0 0 0 0 0 0 ...

bluebird_data <- bluebird_raw
bluebird_data$LATITUDE <- as.numeric(bluebird_data$LATITUDE)
bluebird_data$LONGITUDE <- as.numeric(bluebird_data$LONGITUDE)

landcover_cols <- c(
  "Shallow_Ocean", "CoastShore_lines", "Shallow_Inland", "Deep_Inland",
  "Moderate_Ocean", "Deep_Ocean", "Evergreen_needle", "Grasslands", "Croplands",
  "Urban_Built", "Barren", "Evergreen_broad", "Deciduous_needle",
  "Deciduous_broad", "Mixed_forest", "Closed_shrubland", "Open_shrubland",
  "Woody_savannas", "Savannas"
)

bluebird_data$landcover_total <- rowSums(bluebird_data[, landcover_cols], na.rm = TRUE)
bluebird_data$landcover_total_over_100 <- bluebird_data$landcover_total > (100 + 1e-6)

```

```
data.frame(
  rows = nrow(bluebird_data),
  columns = ncol(bluebird_data)
)
```

```
##    rows columns
## 1 64724      25
```

```
head(bluebird_data, 5)
```

```
##  LATITUDE LONGITUDE      ELEV Shallow_Ocean CoastShore_lines Shallow_Inland
## 1 35.27266 -76.61289   2.24365          0          0          0
## 2 35.95440 -78.94340 100.91523          0          0          0
## 3 36.72264 -81.48981 939.29868          0          0          0
## 4 37.02214 -79.46737 212.17029          0          0          0
## 5 37.29057 -80.45833 773.57905          0          0          0
##  Deep_Inland Moderate_Ocean Deep_Ocean Evergreen_needle Grasslands Croplands
## 1          0          0          0      40.816327   2.040816          0
## 2          0          0          0      0.000000   0.000000          0
## 3          0          0          0      0.000000   0.000000          0
## 4          0          0          0      2.040816   0.000000          0
## 5          0          0          0      0.000000   0.000000          0
##  Urban_Built Barren Evergreen_broad Deciduous_needle Deciduous_broad
## 1    0.00000    0          0          0          0.00000
## 2   63.88889    0          0          0          0.00000
## 3    0.00000    0          0          0      100.00000
## 4    0.00000    0          0          0      10.20408
## 5    0.00000    0          0          0      100.00000
##  Mixed_forest Closed_shrubland Open_shrubland Woody_savannas Savannas y
## 1    51.02041          0          0      4.081633      0 0
## 2    11.11111          0          0     25.000000      0 0
## 3     0.00000          0          0     0.000000      0 0
## 4    85.71429          0          0     2.040816      0 0
## 5     0.00000          0          0     0.000000      0 0
##  landcover_total landcover_total_over_100
## 1      97.95918          FALSE
## 2     100.00000          FALSE
## 3     100.00000          FALSE
## 4     100.00000          FALSE
## 5     100.00000          FALSE
```

Step 3: Examine the data

We inspect the loaded data frame to confirm that values sit within expected ranges and to flag any issues that may require cleaning.

Invalid values

```
range_summary <- data.frame(
  lat_min = min(bluebird_data$LATITUDE, na.rm = TRUE),
  lat_max = max(bluebird_data$LATITUDE, na.rm = TRUE),
  lon_min = min(bluebird_data$LONGITUDE, na.rm = TRUE),
  lon_max = max(bluebird_data$LONGITUDE, na.rm = TRUE),
  elev_min = min(bluebird_data$ELEV, na.rm = TRUE),
```

```
elev_max = max(bluebird_data$ELEV, na.rm = TRUE)
)
range_summary
```

```
##    lat_min lat_max lon_min lon_max elev_min elev_max
## 1 35.00075 49.98552 -84.99986 -70.00072 -17.71138 1862.057
```

Coordinates fall within the eastern United States and southern Canada, and elevations remain plausible for terrestrial sites.

Missing values

```
missing_counts <- colSums(is.na(bluebird_data))
missing_counts[missing_counts > 0]
```

```
## named numeric(0)
```

No missing values are present, so downstream analyses can proceed without imputation.

Data format

```
site_keys <- paste(bluebird_data$LATITUDE, bluebird_data$LONGITUDE)
site_table <- table(site_keys)
total_sites <- length(site_table)
max_records <- max(site_table)
sites_with_duplicates <- sum(site_table > 1)
pct_sites_with_duplicates <- round((sites_with_duplicates / total_sites) * 100, 2)
duplicate_summary <- data.frame(
  total_sites = total_sites,
  max_records = max_records,
  sites_with_duplicates = sites_with_duplicates,
  pct_sites_with_duplicates = paste0(pct_sites_with_duplicates, "%")
)
duplicate_summary
```

```
##    total_sites max_records sites_with_duplicates pct_sites_with_duplicates
## 1      36434         51          9296          25.51%
```

Repeated latitude/longitude footprints suggest the data contain multiple surveys per site. Any train/test split should keep replicated footprints together.

Column names

```
data.frame(column = names(bluebird_data))
```

```
##           column
## 1      LATITUDE
## 2     LONGITUDE
## 3         ELEV
## 4   Shallow_Ocean
## 5 CoastShore_lines
## 6   Shallow_Inland
## 7     Deep_Inland
## 8   Moderate_Ocean
## 9     Deep_Ocean
```

```
## 10      Evergreen_needle
## 11      Grasslands
## 12      Croplands
## 13      Urban_Built
## 14      Barren
## 15      Evergreen_broad
## 16      Deciduous_needle
## 17      Deciduous_broad
## 18      Mixed_forest
## 19      Closed_shrubland
## 20      Open_shrubland
## 21      Woody_savannas
## 22      Savannas
## 23      y
## 24      landcover_total
## 25 landcover_total_over_100
```

Column names already use underscores, so we keep them as provided.

Variable type

```
variable_types <- data.frame(
  column = names(bluebird_data),
  class = sapply(bluebird_data, function(x) paste(class(x), collapse = ", "))
)
variable_types
```

```
##           column  class
## LATITUDE      LATITUDE numeric
## LONGITUDE     LONGITUDE numeric
## ELEV          ELEV numeric
## Shallow_Ocean Shallow_Ocean numeric
## CoastShore_lines CoastShore_lines numeric
## Shallow_Inland Shallow_Inland numeric
## Deep_Inland    Deep_Inland integer
## Moderate_Ocean Moderate_Ocean numeric
## Deep_Ocean     Deep_Ocean integer
## Evergreen_needle Evergreen_needle numeric
## Grasslands      Grasslands numeric
## Croplands       Croplands numeric
## Urban_Built     Urban_Built numeric
## Barren          Barren numeric
## Evergreen_broad Evergreen_broad numeric
## Deciduous_needle Deciduous_needle numeric
## Deciduous_broad Deciduous_broad numeric
## Mixed_forest    Mixed_forest numeric
## Closed_shrubland Closed_shrubland numeric
## Open_shrubland  Open_shrubland numeric
## Woody_savannas  Woody_savannas numeric
## Savannas        Savannas numeric
## y              y integer
## landcover_total landcover_total numeric
## landcover_total_over_100 landcover_total_over_100 logical
```

Predictors are numeric, and the response *y* remains coded as 0/1. If factor semantics are required, the

conversion can occur closer to modeling.

Data specific explorations

```
landcover_stats <- data.frame(  
  min_total = min(bluebird_data$landcover_total, na.rm = TRUE),  
  p10_total = as.numeric(quantile(bluebird_data$landcover_total, 0.10, na.rm = TRUE)),  
  median_total = median(bluebird_data$landcover_total, na.rm = TRUE),  
  mean_total = mean(bluebird_data$landcover_total, na.rm = TRUE),  
  p90_total = as.numeric(quantile(bluebird_data$landcover_total, 0.90, na.rm = TRUE)),  
  max_total = max(bluebird_data$landcover_total, na.rm = TRUE),  
  pct_over_100 = paste0(round(mean(bluebird_data$landcover_total_over_100, na.rm = TRUE) * 100, 2), "%")  
)  
landcover_stats
```

```
##   min_total p10_total median_total mean_total p90_total max_total pct_over_100  
## 1    54.7619      100          100   105.9745   130.5556       200      18.92%
```

Land cover totals cluster around 100 but occasionally exceed it, reinforcing the need to confirm whether overlapping buffers or stacked categories generated the export.

Step 4: Clean the data

The cleaning workflow below:

1. Copies the raw table and stores latitude/longitude as numeric values.
2. Computes land cover totals and flags rows where totals exceed 100.
3. Adds normalized land cover fractions so each record sums to one even if the original totals differ.
4. Aggregates to a site-level table (one row per latitude/longitude) with counts of replicate observations and simple presence summaries. This reduces leakage when splitting data by location.

```
bluebird_simple <- bluebird_data  
  
for (col in landcover_cols) {  
  new_name <- paste0(col, "_frac")  
  bluebird_simple[[new_name]] <- ifelse(  
    bluebird_simple$landcover_total == 0,  
    0,  
    bluebird_simple[[col]] / bluebird_simple$landcover_total  
  )  
}  
  
site_counts <- aggregate(y ~ LATITUDE + LONGITUDE, data = bluebird_simple, length)  
names(site_counts)[3] <- "n_observations"  
  
presence_any <- aggregate(y ~ LATITUDE + LONGITUDE, data = bluebird_simple, function(x) as.integer(any(x)))  
names(presence_any)[3] <- "presence_any"  
  
presence_rate <- aggregate(y ~ LATITUDE + LONGITUDE, data = bluebird_simple, mean)  
names(presence_rate)[3] <- "presence_rate"  
  
elev_mean <- aggregate(ELEV ~ LATITUDE + LONGITUDE, data = bluebird_simple, mean)  
names(elev_mean)[3] <- "elev_mean"  
  
landcover_total_mean <- aggregate(landcover_total ~ LATITUDE + LONGITUDE, data = bluebird_simple, mean)  
names(landcover_total_mean)[3] <- "landcover_total_mean"
```

```

site_level <- merge(site_counts, presence_any, by = c("LATITUDE", "LONGITUDE"))
site_level <- merge(site_level, presence_rate, by = c("LATITUDE", "LONGITUDE"))
site_level <- merge(site_level, elev_mean, by = c("LATITUDE", "LONGITUDE"))
site_level <- merge(site_level, landcover_total_mean, by = c("LATITUDE", "LONGITUDE"))

```

```

bluebird_clean_list <- list(
  cleaned = bluebird_simple,
  site_level = site_level
)

```

```

site_overview <- data.frame(
  sites = nrow(site_level),
  mean_records_per_site = mean(site_level$n_observations),
  max_records_per_site = max(site_level$n_observations)
)
site_overview

```

```

##   sites mean_records_per_site max_records_per_site
## 1 36434             1.776473             51

```

```

columns_to_show <- c(
  "LATITUDE", "LONGITUDE", "ELEV", "landcover_total",
  "landcover_total_over_100", "Woody_savannas", "Woody_savannas_frac", "y"
)
head(bluebird_clean_list$cleaned[, columns_to_show], 5)

```

```

##   LATITUDE LONGITUDE      ELEV landcover_total landcover_total_over_100
## 1 35.27266 -76.61289   2.24365      97.95918             FALSE
## 2 35.95440 -78.94340 100.91523     100.00000             FALSE
## 3 36.72264 -81.48981 939.29868     100.00000             FALSE
## 4 37.02214 -79.46737 212.17029     100.00000             FALSE
## 5 37.29057 -80.45833 773.57905     100.00000             FALSE
##   Woody_savannas Woody_savannas_frac y
## 1         4.081633         0.04166667 0
## 2        25.000000         0.25000000 0
## 3         0.000000         0.00000000 0
## 4         2.040816         0.02040816 0
## 5         0.000000         0.00000000 0

```

```

head(bluebird_clean_list$site_level, 5)

```

```

##   LATITUDE LONGITUDE n_observations presence_any presence_rate elev_mean
## 1 35.00075 -80.63416           1           0           0 204.21820
## 2 35.00108 -79.06775           1           0           0  69.19665
## 3 35.00395 -83.17117           1           0           0 794.37719
## 4 35.00684 -80.63347           1           0           0 198.29341
## 5 35.00952 -83.32141           1           0           0 1077.04045
##   landcover_total_mean
## 1                100
## 2                100
## 3                100
## 4                100
## 5                100

```



```

site_stats <- data.frame(
  min_rate = min(bluebird_clean_list$site_level$presence_rate, na.rm = TRUE),
  mean_rate = mean(bluebird_clean_list$site_level$presence_rate, na.rm = TRUE),
  median_rate = median(bluebird_clean_list$site_level$presence_rate, na.rm = TRUE),
  max_rate = max(bluebird_clean_list$site_level$presence_rate, na.rm = TRUE)
)
site_stats

```

```

##   min_rate mean_rate median_rate max_rate
## 1      0 0.05617417      0      1

```

Next steps:

- Confirm the interpretation of land cover totals that exceed 100 and determine whether they require re-normalization or stratified handling.
- Decide on a final export format (CSV, parquet, or RDS) for both the observation-level and site-level tables once metadata questions are resolved.
- Incorporate temporal information if it is available elsewhere so we can respect survey-years during modeling splits.